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Proceedings of the

FIRST NATIONAL SYMPOSIUM ON SHRIMP FARMING

BOMBAY, 16-18 AUGUST 1978

CENTRAL FOOD TECHNOLOGICAL RESEARCH INSTITUTE
REGIONAL CENTRE
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Organised by

The Marine Products Export Development Authority, Cochin
In association with
The Central Institute of Fisheries Education, Bombay,
The Central Marine Fisheries Research Institute, Cochin and
The Central Inland Fisheries Research Institute, Barrackpore.

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FOREWORD

THIS volume contains the papers presented in, and the proceedings of, the First National Symposium on Prawn Farming conducted by the Marine Products Export Development Authority in August, 1978 jointly with the Central Marine Fisheries Research Institute, Central Inland Fisheries Research Institute and the Central Institute of Fisheries Education.

The various scientific papers in this volume present the status of prawn farming work so far done in different parts of India by various agencies.

I hope that these papers would help in the promotion of further research work on prawn farming and practical application of the results of such research work in farmers' fields.

Sd/-
(R. C. CHOUDHURY)
CHAIRMAN
MPEDA

COCHIN
10th JUNE '80

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Inaugural Address

SHRIMP FARMING - A NEW DIMENSION TO THE SCIENTIFIC UTILISATION OF OUR AQUATIC WEALTH

Dr. M. S. SWAMINATHAN *

Indian Council of Agricultural Research, New Delhi.

1. Introduction

The latest FAO projections on fishery products (Fishery Products : supply, demand and trade projections 1975, released in June) contain the following statement.

Since 1971 the rate of growth of world fisheries production has declined sharply. In the fifties it grew at almost 7 percent per annum, in the sixties at a little under 6 percent but in the seventies the rate of increase has fallen to less than 1 percent. The principal cause of this decline has been the collapse of a number of important fisheries exploited largely for the production of fish meal and oil. Among these the most important has been the South-east Pacific anchoveta fishery which in 1976 yielded some 4 million tonnes compared with 12 million tonnes in 1970, but other fisheries, e.g., the Atlanto-Scandian herring, of less absolute size have shown similar proportiona' declines.Total landings of fish for reduction delivered to fishmeal plants which reached a peak of 26.5 million tonnes in 1970 had by 1973 declined to 18.5 million tonnes and although production has since recovered, it is still well short of the 1970 level.

Landings of food fish destined for direct human consumption have by contrast continued to increase throughout the seventies, but even here the rate of growth at 2.5 percent per annum has declined from that achieved in the 1960s.

The basic cause of this decline, as in the case of the reduction fisheries, is the growing number of stocks becoming fully exploited and the rapidly shrinking opportunities for the diversion of fishing effort to new species or areas. Thus, in many developed countries where technological innovation led early to the heavy exploitation of stocks in adjacent waters (e.g. the North Atlantic) there has been little or no increase in food fish production and growth has come mainly from Japan and the U S S R (and other eastern European countries) which have increasingly had to rely on long-dist-

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* Present Address: Secretary, Dept. of Agriculture, Govt. of India, Ministry of Agriculture & Irrigation, New Delhi.

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ance operations. There has also been steady growth in the developing countries, both from long-distance operations and from local resources often exploited by less intensive methods than employed in northern temperate waters.

Much of the development effort in the developing countries, has, however, been directed toward export fisheries (tuna, shrimp etc.) and thus supplies available for direct human consumption in these countries have risen less rapidly than production. In the sixties *per caput* intake in this group of countries as a whole rose by about half a kilogram and in the first half of the seventies by a further 200 grams. In the developed countries there has been a marked difference in the experience of eastern Europe and the USSR where *per caput* consumption rose by some 9 kg in the sixties and a further 3 kg in the first half of the seventies and the countries of Western Europe and North America where consumption has stagnated. Of the other developed countries, only in Japan and Spain has there been any significant increase in *per caput* fish consumption in the past decade.

Two important morals of the situation described above are first, there should be greater interest in making fisheries products available to the local population, particularly to the poorer sections of the community and secondly there has to be greater attention to the scientific management of our living ocean resources.

Over 10,000 years ago, man shifted from being a *food gatherer* to a *food grower* to end the uncertainity in the supply of food (the credit for the domestication of plants and farm animals should probably go to *women* and not to man). In fisheries, we have so far been gatherers of fish and not growers. The Exclusive Economic Zone of 200 miles will provide us with an ocean surface of about 2 millions sq. km. in contrast to the land surface of 3. 28 millions sq. km available to us. While we should fully utilise the opportunities thrown open by the declaration of the Exclusive Economic Zone, it is time that we took to the farming of aquatic organisms in a big way, since this could provide considerable additional employment and income to those below the poverty line and particularly to rural women. I am hence happy that this symposium has been organised by the Marine Products Export Development Authority.

2. Prawns and shrimps contribute a major exploited fishery

During the last three decades, the fisheries of India has shown a steady growth from an annual yield of 0.75 million tonnes in 1951 to 2.3 million tonnes of current production, and it constitutes one of our great assets. Prawns and shrimps form the most economically significant group in the marine and brackish water fishery resources. In the fresh waters, however, they contribute to only a subsistence fishery except in certain regions. About 52 species of prawns and shrimps that are either commercially exploited at present or have great commercial potentials occur in the Indian waters.

Accounting for an average catch of 0.14 million tonnes, this group represents about 13 percent of the total marine fish production of the country. Substantial quantities of prawns and shrimps, estimated at about third of the marine prawn landings are also caught from our estuaries and backwaters.

3. State of the art

Till about two and a half decades back, prawns used to be sent to neighbouring countries in dried or cured form earning an annual revenue of a few million rupees.From this, to-day prawns have assumed an important place especially as a commodity supporting an export trade of sizable magnitude.Frozen prawns alone exported from India in 1977 was 47,239 tonnes valued at about 1,562 million rupees. The prawn fishery consists of penaeid and non-penaeid prawns. The penaeid prawns which constitute about 62 percent of the total prawn landings are the commercially important ones. The fishery is supported by multiple species that co-exist in the fishing grounds and is characterised by wide seasonal and annual fluctuations in abudance. One peculiar feature of the prawn fishery is that most of the penaeid prawns are subjected to exploitation in the juvenile phase. In terms of landings, Maharashtra ranks first with 47.5 percent in prawn production followed by Kerala (30·7%), Andhra Pradesh (5. 5%), Tamil Nadu (4.6%), Gujarat (4.1%), Karnataka (3.8%) and West Bengal and Orissa (3.1%). Although Maharashtra ranks first it should be mentioned that the highest catch of penaeid prawns which are exported comes from Kerala. Until a few years back the prawn fishery was concentrated by and large on the west coast of India. But in recent years exploratory surveys carried out have revealed existence of commercially exploitable stocks of good sized prawns along the east coast which has led to substantial increase in fishing along the coast. Similarly, exploratory surveys carried out along the continental shelf edge and slope of the south-west and south-east coasts have located potentially rich fishing grounds of deep water prawns. These grounds on the south-west coast are about 5,000 sq. km in extent and the magnitude of the harvestable resource from this area has been estimated to be about 5,300 tonnes per year. These resources are, however, not being fully utilized because of distant location of the ground and the limited demand for the varieties of prawns available there.

The prawn landings in tonnes for the last 10 years are given below:

Year	*Penaeid*	*Non-penaeid*	*Total*
1968	69,514	31,922	1,01,436
1969	72,133	33,964	1,06,097
1970	88,972	26,229	1,15,201
1971	73,320	76,648	1,49,968
1972	74,268	85,488	1,59,756
1973	1,36,514	66,955	2,03,469
1974	1,14,934	55,244	1,70,178
1975	1,41,713	79,038	2,20,751
1976	1,11,640	76,787	1,88,427
1977	86,069	54,227	1,40,296

It would be seen from the above data that there has been a rather steady increase in the catch of penaeid and non-penaeid prawns which after reaching a peak in 1975 have shown a

decline. It is also reported that there is a steady decrease in the size of the prawns as well as catch per unit effort. Due to the entry of a large proportion of small sized prawns in the export trade there has been a tendency for decrease in the unit value realised from export. In this connection the recent meeting organised by the Marine Products Export Development Authority to consider the question of ban on export of 'Thelly' is relevant (Thelly is a Malayalam term used in Central Kerala for the small sized prawns caught from estuaries, backwaters and seasonal perennial prawn culture fields). By and large the most dominant species is *Metapenaeus dobsoni*. During the discussions it became obvious that there are definite indications of over fishing of prawns and that suitable conservation measures will have to be enforced which may include restrictions on the backwater fishery of juveniles. One important suggestion is that the post-larval prawns collected from backwaters should be used for culture operations rather than for export. However, some experts are of the view that development of prawn farming should be based exclusively on prawn seed raised in hatcheries and that the small sized prawns which are now being caught from backwaters should be allowed to be exported failing which the economy of the traditional fishing sector would be seriously affected. It is relevant to mention here of a case where timely warning given by the scientists about the need for conservation was not seriously taken leading to a complete failure of the fishery. In the late 1960s a warning was given about the declining trend in the fishery of the giant freshwater prawn, *Macrobrachium rosenbergii*, of the Kuttanad area and the need for conservation measures. The lack of timely action and probably the effect of constructions of the Thanneermukkom bund resulted in the complete failure of this fishery. It is also believed that consequent on certain river valley development projects the freshwater prawn fishery of *Macrobrachium malcolmsonii* in the rivers of Ganga, Tapti, Choghra have been reduced to a few kilograms per year or have completely disappeared in certain regions in U.P. There are other similar instances of finfish and it all points to the inescapable conclusion that scientific management of the renewable resources, especially those which are subjected to very high intensity of exploitation, should be practised in order to maintain the maximum sustainable yield. This would no doubt involve socio-economic problems and it is necessary that the fishermen as well as the industry should be properly educated and convinced of the need for scientific resource management of natural resources.

4. Exploitation of the resource

The prawn fishery of our country is both dynamic and complex. It is supported by multiple species that coexist in the same fishing grounds; the commercial penaeid prawns are subjected to exploitation in the juvenile and adult phases of their life in two different ecosystems of estuaries/backwaters and sea; wide fluctuations in the catch are observed in all the regions.

Nevertheless their biological features such as their capacity to produce large

number of eggs, protracted breeding season, faster rate of growth, short life span and their ability to withstand wide environmental changes help to maintain their population. However, the exploitation on prawn resources from the wild stock has, in recent years, increased so rapidly that in certain centres of our coast, it has almost reached or has already reached the optimum level. In our efforts of seeking additional resource, one of the ways resorted to is to culture suitable prawns in enclosed fields under controlled conditions.

5. Prawn culture was a neglected field

Unfortunately, this field received the least attention in our earlier plan programmes, though realisation of its importance stimulated several countries like Japan, Taiwan, Republic of Korea, Philippines and United States of America to assign high priority in their national developmental schemes. In our country, prawns form one of the constituents of the brackish water fish culture practised, traditionally on a limited area in Kerala and West Bengal. Here, the fields are simple contrivances impounded by bunds, source of prawns seed is from the wild stock brought in by the incoming tidal currents; culture practice neither involves any husbandry nor management. Prawns are allowed to grow in the fields for a short period, feeding on the natural food available in the environment. Thus the success or failure of the operation depends largely on the availability of seeds in the nature, and the biotic and abiotic conditions of the field. As a result of this, the production of prawns from this field is very low varying from 500-900 kg/ha/year.

6. Researches on the technology of prawn culture

Following the identification of enormous potentials of prawn farming and the urgent need of developing indigenous expertise in the technology of prawn culture, intensive researches are being carried out by several organisations in our country. The Central Marine Fisheries Research Institute and the Central Inland Fisheries Research Institute are undertaking pioneer research and development works respectively on the culture of marine and freshwater prawns. The Konkan Krishi Vidyapeeth is engaged in the studies of farming of local penaeid and palaemonid prawns. The All-India Co-ordinated Research Project on Brackishwater Fish Farming is undertaking investigations on the culture of prawns in the brackishwaters. Besides, the Central Institute of Fisheries Education, Bombay, the Departments of Fisheries of Gujarat, Maharashtra and Tamil Nadu, and the Universities of Cochin, Kerala, Madras, Madurai, Andhra and Annamalai are also conducting important researches on the subject.

7. Development of indigenous technology

These research efforts have considerably advanced our knowledge on the technique and problems of prawns and three species of palaemonid prawns have been successfully spawned in the laboratory and their larvae reared through different stages upto stocking size under controlled conditions. Fairly good survival rate has been achieved in the rearing experiments. Domestication of one of the species of penaeid prawn,

namely *Metapenaeus dobsoni* under controlled conditions in the laboratory has been reported. The requirements of the culture medium, and environmental conditions have been studied. Techniques of culture of several species of diatoms, zooplankters and of the brime shrimp which form the live food of larval and juvenile phases have been developed. Continuous surveys to locate seed grounds have shown several potential areas in the surf region, estuaries and backwaters along the coast. Some data on the techno-economic viability of the culture operation are also available. In a recent field demonstration carried out at the Santhome Brackish water Fish Farm at Madras with the monoculture of *Penaeus monodon*, in a 1.14 ha pond, a production of 587 kg valued at Rs 32,210/- was obtained during a culture period of 80 days. In another demonstration project undertaken at Narakkal in the canals in the coconut groves, the production of *Penaeus indicus* was 492 kg/ha valued at Rs 8,500/-. The expenditure involved was estimated at Rs 2,217. The duration of culture was 89 days.

To sum up, the field experiments carried out at different centres have clearly shown that:

(1) the prawns grow very fast and reach marketable size within 3-4months;

(2) by intensive culture, a production rate of above 1000-1500 kg/ ha/ year could be obtained;

(3) penaeid prawns can be cultured in different types of ecosystems including the derelict waters such as salt pans and shallow canals in the coconut groves; and

(4) the techniques of culture could easily be taken up and followed by even the illiterate farmers.

8. Basic resources are available

In addition to the bays and lagoons on the edge of the sea, we have about 2.6 million ha. of estuaries and backwaters. However, only about 20,000 ha of these areas are now utilised for some sort of prawn culture. We have about a dozen species of commercial penaeid and palaemonid prawns biologically suitable for culture. With these basic resources, there is vast potential for development of this field.

9. Potentials of prawn culture

Besides its role in augmenting food production, prawn culture is vitally important for improving rural economy, and for providing gainful self-employment for large number of fishermen/fish farmers and other persons in the coastal regions. But to fully utilize the potentials offered in the sector, an integrated approach involving major inputs of research, developmental training, and extension programmes and planning are essential prerequisites. Let me briefly point out the major areas which require concerted efforts to make a breakthrough in this field.

10. Modern prawn culture is multidisciplinary

The modern aquaculture has emerged as a multidisciplinary science. It involves Fishery biology, Marine biology, Microbiology, Botany, Physiology, Nut-

rition, Genetics, Engineering, Soil and water chemistry, Processing technology, Pathology, Therapuetics, Economics, Sociology etc. The culture operation includes selection of species, survey and location of sites construction of farms, controlled breeding and seed production, feed development, culture techniques, monitoring of the stocked prawns, control of diseases, maintenance of water quality, manipulations of environment, harvesting, processing and marketing.

II. Areas which require greater thrust

(a) Seed production

In large scale culture, one of the foremost requirements is the availability of seed as and when required by the farmer. It is well-known that abundance of seed in the wild source fluctuates widely and depends on the spawning success and survival of eggs and larvae. Although we have developed techniques of rearing of prawn larvae in the laboratory on a small scale, mass production of seed is yet to be achieved. This involves not only perfection of the techniques, but also steady supply of spawners. Collection of spawners from the breeding grounds is cumbersome and increases the cost of seed.

(b) Induced breeding reproductive physiology

It is, therefore, essential to intensify researches on the reproductive physiology of prawns with a view to evolve techniques for artificial breeding under controlled conditions, and to standardise the techniques of mass production of seed leading to establishment of viable commercial hatcheries.

(c) Nutritional requirements and culture of live food organisms and formulation of artificial feed

In the seed production and field culture; nutritional requirement of larvae, juvenile and adult prawns is an equally important subject matter. Our current knowledge on the total nutritional requirments of prawns, food assimilation and conversion efficiency is meagre. Techniques of mass culture of live food organisms and of capsulation of artificial feed also need perfection and standardisation.

(d) Farm engineering

Location and selection of suitable sites for prawn farming, construction of farms require knowledge of soil structure, water properties, flow pattern, engineering etc. At present we have little expertise on coastal farm engineering and it is imperative that we develop the field immediately so that viable farms could be constructed.

(e) Prawn pathology

With the slight changes in the quality of the culture medium, very often, the stocked organs become susceptible to various types of diseases, parasites and other pathogenic conditions which often lead to mass mortality. I understand that the information available on diseases and parasites and their control measures is scanty. This aspect needs further investigation.

(f) Prawn genetics

Recent advances in agriculture and livestock development have been mainly due to the discoveries and introduction of fast growing, disease resistent highly productive hybrid varieties. These discoveries are essentially based on the knowledge of the genetic resources of the plants and animals. Fish genetics is the least developed subject in our country, and it requires greater stress particularly in view of its importance in maintaining a quality stock for culture.

(g) Harvesting and post – harvest technology

Harvesting and post-harvest technology also require greater attention, when we land on large - scale culture operation and produce large quantities of raw material. I understand that harvesting of prawns from the field is a problem of considerable seriousness. Simple devices which would easily be employed by the farmers will have to be developed. Similarly, low cost processing technology which could be carried out on small scale industrial level has to be evolved.

(h) Proven information on economic viability essential

One of the reasons for the slow progress of prawn culture industry is the scarce flow of finance and hesitation to invest and promote the enterprise due to lack of information on the economic viability of the culture operation. It is well-known that the economics of prawn culture is location-specific. Efforts are being made to demonstrate the techno-economic feasibility of prawn culture through National demonstration project and operational research projects.

(i) Synergy and Recycling in prawn culture

Prawn culture being essentially rural-based in the coastal region and inland freshwaters, it can play a vital role in improving the socio-economic conditions of the individual fishermen as well as the community. It is shown that the prawns can be cultivated in small water bodies such as the canals in between the coconut groves. There is wide scope for synergetic combination of prawn-livestock-crop farming making the best use of the entire farm ecosystem. This concept of synergy and organic recycling is now gaining importance in certain Southeast Asian countries, like Philippines and Malaysia where animals such as pigs and ducks, aquatic plants and fish are raised together. We have already a system of paddy and prawn culture. Systematic evaluation of these systems and introduction of combination or polyculture techniques and better management can revolutionise production and considerably enhance the rural economy.

12. Integrated Sea Farming and Home Prawn gardening

Another area which can contribute significantly and accelerate the rural development is raising of prawns in small enclosures in the coastal waters in conjunction with the capture fishery activities. In fact, the features of prawns such as fast growth rate, omni-

vorous feeding habits and hardiness make them also ideally suitable for "Kitchen gardens" in the area having small ponds and canals.

13. Training of prawn farmers

Successful adaptation of the technologies and their wide propagation depend on the extension and training facilities available in the field. Unfortunately we are lagging far behind in this respect. It is only recently that the importance of training of farmers in prawn/fish culture was realised and a beginning has been made with the establishment of the Krishi Vigyan Kendra at Narakkal which provide training on mariculture including coastal aquaculture, and the other at Dhauli which offers training in inland fish culture. As we require large number of operational and trained farmers for the development and establishment of intensive prawn culture on large scale arrangements will have to be made immediately to meet the training requirements.

14. Extension services

The starting point in the rational development of any resources is the accessibility of information at various levels. This is a prime and continuing task. A strong extension service aimed at making the results of the new technologies, to the actual man-in-the field is urgently needed. While developing the extension services, some of the principles involved in the 'Training and Visit' method of agricultural extension could be adopted. Women should be given training in the latest technology. Illiterate women in our country are endowed with the capacity to work hard and if given training they will do an excellent job.

15. Constraints and pre-requisite

For the large scale application of farming techniques to the breeding and rearing of prawns there are several constraints. The technique of induced breeding of prawns will have to be developed to a stage when the ordinary fish farmers could adopt this. The availability of fry resources is another constraint. While development of induced breeding and rearing of marine prawns to obtain adequate quantity of stocking material for taking up commercial farming operations may take time, the seed available from the natural sources could certainly be made use of. In the Philippines the habit of the post-larvae of *P. monodon* clinging to weeds is being made use of by fishermen to collect them in large quantities for culture operations. Fortunately the commercially important Indian penaeid prawns breed throughout the year and post-larvae of these could be collected in large quantities from backwaters adjacent to the coast, estuaries and surf area. Another constraint relates to the ownership and leasing policy of water areas owned by the Government. The engineering aspects of construction and maintenance of farms, which are location specific, training of fishermen fish farmers in the new techniques evolved, lack of information of the cost-benefit-ratio of prawn culture operations under different ecological conditions and non-availability of financial support for farm construction and other expenditure connected with prawn

farming are some of the other constraints.

The training aspect is being taken care of by the establishment of Krishi Vigyan Kendras and it is hoped that the tempo of transfer of technology will be accelerated soon thereby reducing the accomplishment gap. Pilot-scale projects are also being initiated to demonstrate the economic and technical viability.

Capture fisheries is becoming more and more capital intensive especially with the raising cost of fuel and energy. Although culture fisheries cannot replace capture fisheries, they would certainly supplement and augment the total yield. Considering the prevailing conditions in our country the immediate prerequisites for successful prawn culture operations would be (i) long-term availability of water areas for prawn farming, (ii) an assured supply of stocking material collected either from natural sources or through hatchery operations, (iii) improvement of prawn culture practices and development of a package of management practices to suit varying ecological conditions, (iv) adequate training of operatives, (v) low interest bank loans and (vi) appropriate public policies in the area of pricing processing and marketing both in India and abroad .

In fisheries development we are in a stage of historic transition. So far, we have been mainly capturing what occurs in nature. Now we are moving towards domestication and culture. This will provide altogether new vistas of production and prosperity as well as altogether new problems and challenges. New diseases and management problems may occur. We should train ourselves to carry out careful impact analysis from the socio-economic ecological and scientific angles, so that we remain prepared when new problems arise. The I. C. A. R. proposes to establish a National Bureau of Fish Genetic Resources to preserve the genetic variability occuring in aquatic organisms. Also during 1979 which marks the completion of 50 years of service to Indian agriculture by I. C. A. R. a massive programme of demonstrations and training in both inland aquaculture and mariculture will be initiated. I hope this Symposium will help to sharpen our priorities and programmes in shrimp farming.

The Inagural Address was presented by Shri. P. R. S. Thampi, on behalf of Dr. Swaminathan.

SHRIMP FARMING IN INDIA PRESENT STATUS AND FUTURE PROSPECTS

K. H. ALIKUNHI

Fisheries Advisor, Govt. of Kerala, Trivandrum

1. Resources

Scientific aquaculture is a profitable industry and is the hope of the future for augmenting fish production. Besides a variety of extensive, freshwater habitats, millions of hectares of estuarine swamps, mudflats, backwaters and coastal seas offer tremendous potential resources to be developed and harnessed for aquaculture. Fast growing marine shrimps like the tiger prawn *Penaues mondon* and the white prawns, *P. mer guiensis* and *P. indicus* are plentiful in Indian waters and young ones of these species abound in tidal creeks and coastal shallows during specified seasons. The giant freshwater prawn, *Macrobrachium rosenbergii* is widely distributed throughout the country and is suitable for culture in freshwater ponds and reservoirs.

2. Present status

Extensive work has been carried out in the country on the biology, breeding, development and fishery of almost all commercially important species of marine and freshwater prawns occurring in our waters. Seed surveys have been carried out on a limited scale and some information is available on the natural occurrence and abundance of post-larvae and juveniles of the tiger prawn *P. monodon*. Farming trials have so far been limited and of an experimental nature. Trapping juvenile prawns with the incoming tide in fields and similar impoundments and allowing them to grow before harvesting, represented by the traditional practices of prawn filtration in Kerala and Bhasha Badha fisheries in Bengal clearly indicate possiblities of profitable prawn culture, if scientific practices of stocking and management are adopted.

Realising that seed is the main bottleneck in organising shrimp farming, the Central Marine Fisheries Research Institute has established at Narakkal a pilot scale hatchery where several species of marine prawns have been bred and larvae reared. Successful mass rearing of penaeid larvae in plastic pool hatcheries on a purely artificial diet consisting of *Acetes* spp. has been carried out at the Central Insitute of Fisheries Education, Bombay. Some progress has been made on the larval rearing of *M. rosenbergii* by the Central Inland Fisheries Research Institute at

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*Key-note address delivered by Shri K. H. Alikunhi.

Kakinada, though largescale production is yet to be achieved.

3. Seed collection industry

Adequate, timely supply of quality seed is fundamental to any organised farming programme. Utilisation of available, natural resources is the priority consideration in this regard. In neighbouring countries like Indonesia and Philippines collection of milkfish and shrimp fry from natural sources is an organised industry. In Indonesia alone the seed collection industry provides employment for 10,000 persons and the annual collection of *P. monodon* postlarvae and juveniles amount to over 400 million. In india, the limited seed surveys so far carried out indicate fairly good collections, particularly of *P. monodon.*

The first step, therefore, in encouraging shrimp farming is to organise a regular seed collection industry. Simple scoop nets, push nets, drag nets or lure lines could be used to collect post-larvae. Interested people along coastal areas should be shown the operation of such nets/gear and the correct methods of handling, segregation and storage of post-larvae. As an incentive for continued collection, there should be a ready market for the collected post-larvae. Perhaps, the concerned Panchayats could buy the post-larvae from the collectors at a reasonable price and when sufficient stocks accumulate, sell them to shrimp farmers. Arrangements for transportation of seed under oxygen packing could also be made by the Panchayat, at a nominal charge. An alternative would be organisation of seed supply cooperatives. Fisheries extension agencies could organise necessary training, at Panchayat level on all aspects of seed collection, storage and transport.

In order to get the collection programme started, it may be necessary initially, to supply free of charge nets and containers for storage of seed. Some Government agency like the Marine Products Export Development Authority should come forward to do so.

4. Seed production in hatcheries

Seed collections from natural sources will fluctuate from season to season, from year to year and from centre to centre; and often bulk supplies for large scale farming operations become difficult, taking several days for accumulation and incurring considerable mortality during storage. Controlled breeding of prawns in hatcheries and mass rearing of larvae ensure adequate supplies of uniform size, quality seed for large-scale farming operations. Thus establishment of hatcheries for large-scale seed production assumes the same priority as organising the seed collection industry.

Unlike seed collection from natural sources, mass rearing of shrimp larvae in hatcheries is a highly sophisticated technology and hatchery operators will need intensive training to ensure successful operations. This will have to be organised within the country as well as outside. Detailed considerations of a model shrimp hatchery form one of the topics for discussion during our deliberations. Establishment of one or more hatcheries in each maritime state

would go a long way in solving the seed problem for commercial shrimp farming operations.

To ensure this, the central fisheries research and educational institutions should establish and maintain model hatcheries for continuous experimentation to evolve new and improved techniques of hatchery management; while other central government agencies should come forward with financial support to meet the relatively high cost on capital expenditure in the establishment of hatcheries.

Organised culture of *Macrobanchium* is almost non-existent in India at peresent, because of non-availability of seed for stocking. Though hatchery conditions are different and the larval cycle takes a much longer period than penaeid shrimps, mass rearing of larvae of *M. rosenbergii* can be taken up in penaeid shrimp hatcheries as an additional activity.

5. Induction of maturation and spawning

For successful, commerical operation of a shrimp hatchery regular supply of spawners throughout the year has to be assured. Induction of gonadial maturation in pond grown stocks of selected species now appears to be the best method to ensure this. To this end, each hatchery should have as an adjunct a small experimental farm in which fast growing species, selected from particular brood parents can be reared to the desired size and then operated upon to induce gonadial maturation. Such a farm would be essential also when selected, species of fishes like *Mugil cephalus Lates calcarifer, Chanos chanos* etc are to be produced for induced breeding when polyculture programmes are to be taken up for increased production. Nursery ponds in the farm have to be used for the regular programmes of raising shrimp post-larvae to juvenile stages.

6. Farming operations

The first phase of shrimp farming is rearing hatchery produced post-larvae in nurseries to the juvenile stage. Nursery pond operation is somewhat different from raising a marketable crop. Rearing post-larvae to juvenile stage and stocking them in production ponds will reduce duration of the production cycle and would generally give better survival than when post-larvae are directly stocked into production ponds While nursery ponds could and should be provided in all large farming complexes small operators generally would not have this facility. In order to provide the juvenile prawns ready for stocking, it is worth considering development of a "fingerling supply trade" which, to avoid long distance transportation, will have to be on a district level.

Ponds for shrimp farming have to have atleast one metre depth of water. Initial preparation of ponds prior to stocking should include eradication of predators and all unwanted fish; making sure that the sluices and screens are in proper condition; leakages if any in the dykes are securely plugged and that the pond has been suitably manured to encourage food production.

Supplementary feeding of stock with compounded artificial feed is necessary to increase production. Daily feed requirements would be considerable in large farming units and it might be cheaper for such enterprises to have adequate machinery installed to process the feed as wet or dry pellets. For small-scale farmers an inexpensive method of processing the feed at home, using simple, manually operated extrusion gadgets should be adequate, if processed feed is not otherwise locally available.

Harvesting the shrimps often creates problems. If the pond can be drained at low tide, the crop can be handpicked with the aid of scoop nets, etc. For larger ponds it is advisable to provide a harvesting basin, in the form of a small, rectangular, earthen dyke pond, adjoining the pond sluice and installing a second sluice on the dyke opposite. Adjusting the water level by manipulating the two sluices some of the prawns from the stock pond could be attracted to crowd in the harvesting basin and from where taken out by small scoop or dip nets. Trapping is a common method for periodic, partial harvesting of prawns.

In encouraging shrimp farming operations items like pumps, sluices, screens, fertilisers, feed raw material and feed processing machinery, etc, could be provided by Government agencies as loans, subsidies or even as outright grant. In the initial phase all types of inducements are necessary to give the people confidence to venture into farming operations.

SUMMARY PROCEEDINGS OF THE NATIONAL SYMPOSIUM ON SHRIMP FARMING

SESSION I- SHRIMP FRY RESOURCES

16-8-1978

Chairman	-	Dr. E. G. Silas
Rapporteur	-	Mr. M. S. Muthu

The session opened with Chairman's observation that the biggest constraint in the development of shrimp culture on large scale was the non-availability of seed in sufficient quantities at the right time. The 12 papers to be discussed on this subject during the session were then grouped under 4 heads as follows:

I. Larval rearing techniques

1. Alikunhi, K. H.,	Role of hatcheries in commercial farming of penaeid shrimp.
2. Alikunhi, K. H., and K. Hameed Ali,	Induction of maturation and spawning in pond grown stocks of penaeid shrimp for large scale seed production.
3. Hameed Ali, K., and S. N. Dwivedi,	Semi-commercial hatchery for large scale rearing of penaeid prawn larvae.
4. Hameed Ali, K.,	Preliminary experiments on mass rearing of penaeid larvae on cheap artificial feeds.
5. Halder, D. D.,	Breeding of *Penaeus monodon* in Farm Pond under captivity.
6. Reddy S. R., M. Q. Ahmed, P. K. Joshi, and S. N. Dwivedi,	Preliminary investigations on the rearing of post-larval stages of *Penaeus merguiensis* on mysids to stockable stages.

II. Seed from natural resources

7. Kuttiyamma, V. J., and C. V. Kurien, — Prawn fry resources in the Kayamkulam lake

8. Subramanian, P., S. Sambasivan and K. Krishnamoorthy, — A survey of natural communities of juveniles of penaeid prawns.

9. Victor Chandra Bose, V. Venkatesan and D. Sundararajan, — prawn seed resources of Adayar estuary at Madras.

III. Rearing of Macrobrachium

10. Joseph, K. S. — Notes on *Macrobrachium rosenbergii*, the giant freshwater prawn, its larval rearing and culture with Indian and exotic carps.

IV. Shrimp seed requirements

11. Vedavyasa Rao, P., — Seed requirements for intensive culture of penaeid prawns in coastal waters, particularly in Kerala.

12. Mammen, T. A., *et al* — Procurement of fry by MPEDA.

The salient features of these papers were presented by authors, except in respect of paper 7, where the authors were not present for presentation.

The recent development of induced maturation and breeding of shrimps by eye stalk ablation technique was discussed in greater detail.

When Shri P.C. Raje asked whether re-maturation of gonads was a continuous and repetitive process after ablation of eye stalks, the Chairman clarified that *P. monodon* in Philippines was known to remature upto 10 times after eye stalk ablation. Dr: Ramamurthy asked whether successive rematurati on led to loss of fecundity. Shri Alikunhi replied that while the prawn produced lesser numbers of eggs in subsequent rematurations, there was no loss in virility of the larvae produced. Dr. P. V. Rao added that according to the experiments carried out in Philippines, the fecundity of *P.monodon* declined with repeated rematurations; the percentage of rematuring females also went down. Dr. Rao desired to have more information about the reported ability of eye

stalk ablated *P. monodon* to impregnate eye-ablated females of *P. indicus*.

Shri K. H. Alikunhi reported his successful experiments on the procuction of hybrid shrimps that were growing up vigorously. He cautioned that water quality and feeding were important in the induced maturation of shrimps and added that if these conditions are optimal 100% maturation is possible. The Chairman congratulated Shri Alikunhi on the success achieved in producing hybrid prawns and said that it opened up immense possiblities in genetic improvement of shrimp stocks.

Shri P. S. Rao wanted to know whether the breeding techniques developed now could be handed over to the farmers and whether this technology is useful for our country. Shri K. H. Alikunhi felt that the technology could be used by farmers and the farmer would raise larvae as a cottage industry. The lack of sufficient information on the shrimp seed resources in many Maritime States was another major point for discussion. It was suggested by Shri G. N. Mitra that standard gear and uniform methods should be adopted for the quantitative estimate of shrimp seed resources to make the data comparable. Shri G. N. Mitra further cautioned that even in places where prawn seed was available in plenty, the local fishermen may not allow them to be collected as it would affect their livelihood and so he advocated that we should rely more on hatcheries and develop them as a cottage industry. The Chairman pointed out that in Kerala there was already strong objection from the fishermen for collecting the prawn seed from the brackishwaters for culture purposes. The need for developing satisfactory transportation technique for shrimp seed was another topic that was discussed. Shri A. P. Valsan wanted to know whether the cannibalism noted by Dr: Mammen among juvenile occured under natural conditions also and whether it happened only when starved at the time of transportation. Shri K. H. Alikunhi felt that there would be no cannibalism, if the larvae were well fed before and during transportation. On this Dr. Mammen wanted to know whethar feeding shrimp in transport would lead to pollution of the water and whether we could develop a feed that would not pollute the water.

Shri Alikunhi clarified that under crowded conditions even slightly weak ones were attacked by the healthy ones that immobilized the former by biting off the pleopods first. He felt that the best way to avoid cannibalism was to transport them in the postlarval stage and keep a cup full of *Brachionus* in the transporting vessel. Transporting larger ones would not be economical. In all these cases accumulation of carbondioxide and not lack of oxygen was the limiting factor in the survival of fry in oxygen filled bags. The Chairman recalled his experience in air lifting 20 mm long juveniles of *P. indicus* to the Andamans in 26 hrs. without any mortality or feeding the larvae before packing. Dr. P. U. Verghese mentioned that while transporting fry, he had kept plastic strips overgrown with periphyton for *P. monodon* fry to graze during transport. This had resulted in better survival. Dr. Dwivedi reported higher survival rate in the transport of

P. monodon seed from Kakinada to Bombay when ice was used to lower the temperature. Shri K. Hameed Ali further explained that about 6000 post-larvae could be transported without mortality at 18° C. At this temperature the oxygen requirement of the larvae is reduced to about half the normal requirement. In the discussion that followed on the rearing of *Macrobrachium rosenbergii* Dr. Dwivedi wanted to know the growth rate of *M. rosenbergii* under culture conditions, compared to natural growth. Dr. P.V. Rao observed that in the Pampa river system *M. rosenbergii* attained a size of 200-220 mm in one year. This was confirmed by Shri K. S. Joseph. Shri K. V. Navathe said that 30 mm juveniles of *M. rosenbergii* reared by the state Fisheries Department in cement cisterns, earthern ponds and in cages reached a size of 290 mm. in 9 months time. Shri U. K. Gopalan attributed the decline of *Macrobrachium* fishery of the Vembanad lake to the construction of the Thanneermukkom bund. He urged that steps should be taken to preserve this valuable species by providing such ecological conditions as are necessary for its well being. The Chairman, summing up the discussion on natural shrimp seed resources stressed the need for developing economically viable methods of transporting prawn seed. He endorsed the view expressed by Sri G. N. Mitra on the need for survey of seed resources and favoured a co-ordinated project on the subject. He announced that a report on the shrimp seed resources of Tamil Nadu and Kerala would be brought out by the CMFRI shortly. But he felt that ultimately for large scale shrimp farming we will have to depend on the hatchery reared shrimp seed, as the supply of the natural seed resources was undependable and bound to decline due to over exploitation of the resources.

The following two papers were included in the session as late abstracts.

1. Alikunhi K. H.-Observation on mass rearing of pelaemonid larvae

2. Alikunhi K. H., K. K. Sukumaran and S. Adisukresno.

Notes on post-larval rearing of penaeid shrimps:

RECOMMENDATIONS

The symposium having noted the non-availability of snrimp seed in the right time and in adequate quantities recommends.

1. Stepping up of efforts by various agencies like ICAR research Institutes, State Fisheries Depts.,Universities, NIO, MPEDA etc. in conducting a survey of shrimp fry rssources occurring in the natural environment, particularly of the two fast growing species viz. *Penaeus mondon* and *P. indicus*.

2. For ensuring comparability of data collected by various agencies, MPEDA may take the lead in prescribing standard gear and uniform methods of operation.

3. The various agencies connected with research, development and extension of shrimp farming techniques should quickly develop the technique of shrimp breeding and related hatchery techniques so that farmers could be encouraged to raise shrimp fry on a cottage industry basis.

SESSION II- CONSTRUCTION AND MAINTENANCE OF SHRIMP FARMS

17-8-1978

Chairman	-	Dr. V. G. Jhingran
Rapporteur	-	Dr. P. U. Verghese

Session II opened with introductory remarks of the Chairman, Dr. Jhingran who briefly outlined the importance of the topic stating, shrimp farming as essentially a coastal aquaculture activity and its needs and requirements are similar to those for fish culture with only certain minor differences.

The following papers were presented at the session.

1. Sengupta, A. K.,	Construction and maintenance of shrimp farms for commercial production.
2. Muthu, M. S.,	Site selection and type of farms for coastal aquaculture of prawns.
3. Reddy, D. V.,	Brackishwater fish farm construction and maintenance.
4. Mukherjee, A. B.,	Design and construction of sluices for shrimp farms in India.
5. Punwani, D. M.,	Materials used in the construction of aquaculture systems.

After presentation of the papers Dr. S. N. Dwivedi, gave a brief talk on farm construction. Dr. Dwivedi stressed the importance of site selection and construction of farms, taking the environment and tidal amplitude into consideration. With the aid of colour slides he gave brief account of farm sites in Goa estuary. He pointed out the need for keeping the construction cost of prawn farms as low as possible in order to make it within the reach of rural farmers. He also gave an account of the progress achieved in converting salt pans into fish farms.

The Chairman then declared the topics open for discussion.

On a point raised by Shri S. K. Pradhan

whether any consideration should be given to the soil composition, in view of the burying habit of prawns, Shri Sengupta explained that under normal soil conditions existing in the farm, the bottom soil would permit the burying habit of prawns. Shri Pradhan pointed out that in Japan a layer of sand is used at the pond bottom to facilitate the prawns to bury.

Shri M. M. Mohanti, initiated discussion on the design of feeder canals. Dr.S.N.Dwivedi and Shri G.N.Mitra joined the discussion and emphasised the need for designing the canals in relation to tidal levels and its variations. Shri G. N. Mitra further pointed out the need of secondary and tertiary canals to feed the ponds.

The need for developing a low cost technology for the construction of coastal shrimp farms was raised by Dr. T. A. Mammen, Shri T. V. RadhaKrishnan and Shri V.Venkatesan who pointed out the necessity of minimizing excavation to keep the cost down. The Chairman invited Shri G. N. Mitra and Shri K. H. Alikunhi to relate their experience on shrimp farm designing, construction and maintenance. Shri G. N. Mitra narrated his experience of farm construction in the Sunderbans at Bakkali and stressed the need for removal of tree stumps and roots from the pond site. He also suggested that farm design should be in accordance with the requirement of species cultivated.

Shri K. H. Alikunhi gave an account of farm construction as practised in Indonesia. He felt that the availability of sufficient tidal amplitude as an important consideration in deciding the extent of excavation. He also considered deeper ponds were good for prawns and milk fish, and pointed out that the shallow Indonesian ponds were not a model to be followed. He described the dyke construction method by using rectangular earthern blocks. The design of sluice gates was discussed and measures for stopping leakage and crab holes in the open top sluice boxes were outlined. For effective exchange of tidal water in the ponds he advocated two main sluices and installation of pumping units in larger farms.

Dr. T. A. Mammen, Dr. V. G. Jhingran, Shri D. V. Reddy and Shri T. V .Radhakrishnan were of the opinion that the top soil containing nutrients may be preserved while digging, to be spread at the pond bottom, after costruction of farm ponds. As an alternative Dr. Mammen suggested construction of bunds with earth transported from elsewhere so as to leave the pond bottom undistrubed.

Shri M. Jayaraj, Director of Fisheries, Karnataka initiated discussion on the difficulty in getting proper site for shrimp farm construction and said that tremendous gaps exist in our knowledge on coastal aquaculture engineering. He suggested setting up of an aquaculture engineering wing in collaboration with fishery biologist at national level. Dr. V. G. Jhingran analysed the merits and demerits of getting the construction work done through departmental agencies and PWD. Prof. Rao, of CIFE informed that cost of construction would be high as the engineers design the farm to stand for a number of years.

Shri D. H. Mhasawade joined in the discussion and wanted information on cost of construction of coastal farms including infrastructural costs. The discussions veered round the view that brackishwater farms construction to be effective should be entrusted to a team consisting of engineers and biologists. As PWD construction is costly and time consuming participants favoured the idea of departmental construction. Against an enquiry, whether consultancy work in shrimp farm construction could be undertaken by MPEDA, Dr. Mammen stated that according to a scheme awaiting sanction, MPEDA has provision for giving extension advice and preparation and evaluation of feasibility reports.

Optimum size of shrimp ponds was another topic that came up for consideration. Dr. P. V. Rao, Dr. V. G. Jhingran Shri K. H. Alikunhi joined in the discussion. It was generally agreed that in the absence of any experimental work in India for comparison, the size adopted in other south-eastern countries may be used as guidelines in the matter.

The proportion of nursery pond and producton pond was enquired by Shri. P. Mohapatra. Shri K. H. Alikunhi and Dr. P. U. Verghese felt that with the present level of management about 10% of farm may be set apart for nurseries, though that would vary depending on factors like efficiency of nursery management, availability of naturally occuring fry, supply of fry to other farms etc.

The physico-chemical factors like dissolved oxygen, temperature and soil productivity were brought up for discussion by Dr. Ranade, Dr. Dwivedi and Shri K. H. Alkunhi. Dr. V. G. Jhingran stressed the need for keeping the dissolved oxygen level high for better growth and survival of prawn. Use of air compressors and air blowers was recommened for this purpose.

Shri Chidambaram wanted a fresh survey to be organised to locate the land areas available for coastal farming and also to identify areas suitable for shrimp farming. He called upon Central Research Institutes and State Directorates to come forward for the survey so that the required information is available to entrepreneurs without delay.

The Chairman pointed out the labour intensive nature of coastal aquaculture and the element of risk involved and particularly cautioned against the risk of poaching. He observed the lack of sufficient number of papers on the subject as indicative of the lack of sufficient importance attached to this important aspect of shrimp farming. He, however, thanked the authors for the papers and participants for stimulating discuissions. The session suggested the following recommendations.

1. Having regard to the vastness of area available and the imperative need to select areas capable of conversion and development as shrimp farms, the session felt that guidelines for a survey of suitable areas should be undertaken.

2. An appropriate technology for shrimp farm construction using cheap and readily available materials, generally in keeping with the rural economy of

the country should be developed.

3. The session identified fish farm engineering as a serious constraint and desired that steps should be taken to develop technology and expertise. The engineers engaged on farm construction should work in close association with biologists. They should also visit existing brackishwater fish farms in India and abroad.

4 The session welcomed the initiative of MPEDA in providing extension advice, as well as facilities for preparation and evaluation of feasibility reports for obtaining bank finance.

5. In order to assist prospective farmers, the session suggested preparation of standard designs for different sizes of shrimp farms.

SESSION III–SHRIMP CULTURE AND ITS ECONOMICS

17-8-1978

Chairman : Dr. S. N. Dwivedi
Rapporteur : Shri D. V. Reddi

The following 16 papers were presented:

(1) Raje, P. C., and M. R. Ranade, — Economical implication of shrimp farming

(2) George, K. V., — Economics of traditional prawn culture practices in Kerala along with a note on the advantage of Intensive Prawn Culture.

(3) Sebastian, M. J., D. M. Thampi, and C. G. Rajendran, — A report on preliminary experiments on tiger prawn culture and seed prospecting with a project proposal for the development of inland prawn farming in Kerala.

(4) Reddi, D. V. — Economics of shrimp farming in Kakinada area.

(5) Verghese, P. U. — Potentials of brackishwater prawn culture in India.

(6)	Sundararajan, P., S. Victorchandra Bose, and V. Venkatesan	Prawn culture at Santhome brackish-water fish farm, Madras.
(7)	Gopalan, U. K., K. S. Purushan, and T. S. S. Rao	Case studies on the economics of an improved method of paddy field shrimp culture in Vypeen Island, Kerala.
(8)	Mhasawade, D. H.,	Scope for prawn culture in Maharashtra State.
(9)	Siddharaju, S., K. M. Mohammed-Sultan, and A. Sreenivasan,	A new system of prawn culture.
(10)	Sankolli, K. N. and Smt. Shakuntala Shenoy	*Macrobrachium malcomsonii*, a prospective competitor for jumbo prawn *M. rosenbergii*
(11)	Sankolli, K. N., Smt. Shakuntala-Shenoy and D. R. Jalihal,	Possible potentially cultivable new species of fresh water prawns in the genus *Macrobrachium*.
(12)	Radhakrishnan, T. V.,	Some problems encountered in commercial shrimp farming.
(13)	Patel, M. I., A. U. Buch, N. D. Chhaya, M. Bhaskaran, and N. K. Vashi,	A proposed project on brackishwater farm at Jodia, Gujarat.
(14)	Mammen, T. A., G. N. Panicker, A. S. Shenoy, Elizabeth Leela George, A. G. Varghese, and K. K. Chandran,	Shrimp farming demonstration by MPEDA
(15)	P. K. R. Panicker and E. S. Kadri	Rearing of *Macrobrachium rosenbergii* in cemented ponds with running water and in Kachha pond with stagnant water.
(16)	P. K. R. Panicker and E. S. Kadri,	Cage culture experiment on culture of *Macrobrachium rosenbergii* (De man).

The economics presented in the papers were debated in greater detail. The participants felt that the lowest rate of profit of 30-35% was quite attractive.

During the discussions Prof. Rao, CIFE,

Bombay (Prof. of Economics) felt that projections should be more realistic. It was pointed out that the cost of land shown in one of the papers at Rs. 2,500/- per hectre was too low and that the price of prawn will fall when its culture is taken up on a large scale. It is clarified that the method of calculating economics was not perfect, but sufficiently realistic and indicative. Dr. T. A. Mammen replied that there was no need to apprehend that the price of shrimp would fall since the export market would absorb any increased production of shrimp. Shri G. N. Mitra mentioned that the projection of economics was generally satisfactory in the existing conditions. Shri D. V. Reddi, confirmed that the price of land, indicated was the prevailing price.

Dr. S. N. Dwivedi pointed out that the cost of capital investment varied from place to place. Shri Jayaraj and others felt that the assumptions on the economics of commerical shrimp hatchery should be more realistic. Shri Jayaraj metioned that the cost of producing 5 to 6 lakhs of shrimp postlarvae from the hatcheries was reported as Rs. 15 lakhs in Thailand. Dr. Silas suggested culture of medium and small size prawns like *M. dobsoni* for our internal market, particularly in view of the abundant seed availability. On the discussion of the size of the shrimp at which it should be harvested, Dr. Mammen mentioned that with 50 gms. and above size fetch best price. Shri S. Gopalan, mentioned that the yield from prawn filtration was around 1,000 kgs. per hectare, but was declining for reasons like washings of pesticides, less recruitment of prawn fry etc. It was suggested that a study for finding out the reasons may be carried out by agencies like CMFRI. The demonstration of shrimp culture taken up in farmers fields in Cochin area gave encouraging results and it should be carried out on extensive scale, it was suggested. There was a suggestion to create extension wings in different institutions and also for starting hatcheries for production of shrimp fry for supply to farmers.

In the discussions on export market patterns, some participants suggested consumer packs, instead of bulk packings to obtain better prices. Shri. S. Gopalan while supporting group marketing for obtaining better price noted that small processors had their own reasons for selling under their own labels.

RECOMMENDATIONS

1) Some studies should be undertaken for projecting the economics of cultivating the prawn in the culture ponds, salt pans and paddy fields.

2) The growth of commercial prawn culture largely depends on the seed availability and before commercial hatcheries come into vogue for supplying seed to the entrepreneurs. Central Institutes should develop hatcheries to supply prawn seed.

3) Extension wings to be created in every institute to carry on the research knowledge in every potential areas. The extension techniques are conducting exhibitions, film shows, fishermen day, radio talks etc. The banks may be convinced to advance loans to entrepreneurs, fish farmers etc.

4) Studies should be undertaken on stocking rates and feeding in different situations for different varieties with a view to find out the commercial viability of prawn culture.

5) Studies should be undertaken to find out the tidal amplitudes at the different areas in different periods in the potential areas.

6) Commercial attaches of our embassy should periodically be advised of our market conditions and problems with respective countries and obtain back the demand and market situations in that country.

SESSION IV–STRATEGY FOR COMMERCIAL SHRIMP FARMING

17-8-1978

Chairman : Shri G. N. Mitra

Rapporteur : Dr. Elizabeth Leela George

Sri G. N. Mitra chaired the session as Prof. P. C. George, Joint Commissioner (Fisheries) could not attend the symposium owing to pre occupations. The following seven experience papers were included for presentation during the session.

1. Silas, E. G.,	Status of prawn culture in India and strategy for its future development.
2. Chidambaram, K.	Strategy for commercial shrimp farming.
3. Venkatesan, V., S. Victor Chandra Bose and D. Sundararajan,	An approach for the development of brackishwater prawn farming in Tamil Nadu.
4. Sanjeeva Raj, P. J.	Pulikat lake as a giant pond for prawn culture under rural science and technology.
5. Kumaradas, P. S.	Strategy for development of commercial shrimp farming in Kerala.
6. Dwivedi, S. N.	Prospects and perspectives in prawn culture.

7. Mammen, T. A., Administrative arrangements for commercial shrimp farming.

Of the seven papers listed, six only were presented by the authors. Dr. P. J. Sanjeeva Raj was not present and his paper was not read out formally.

Dr. Silas in his paper emphasised three basic approaches for increasing production: (1) expanding area of operation (2) application of existing technology in the area under operation (3) application of improved/advanced technology.

He stressed the need for mass production of seed as a pre requisite for large scale shrimp farming. Detailed survey of seed resources and perfection of techniques of hatchery were identified as areas requiring immediate action. He also stressed the need for a suitable technology for transportation of seed produced in hatcheries and their distribution to farmers.

P. indicus and *P. mondon* were identified as the two species of importance from national point of view for intensive culture, occuring along both east and west coasts. *P. merguensis* along the Maharashtra coast, and *P. semisculcatus* along the south east coast were identified as species of regional importance.

Dr. Silas emphasised the immediate need of perfection of techniques on hatchery production, domestication of selected species, improvement of the stock, development of live feed and artificial feed as some of the pre-requisites for development of large scale hatchery system. In field operation, selection of suitable sites, designing and construction of farm, regular monitering of stocked prawns, prevention from pollution damages, harvesting and farm management were listed as important aspects. For optimum utilisation of the pond water ecosystem integrated culture of prawns with compatible species of fishes such as mullets, milk fish and pearl spot was also suggested.

Shri. K. Chidambaram outlined the general conditions required for establishing prawn farms and problems and constraints encountered in the efforts to develop areas like mangroves, estuaries, lagoons and backwaters for aquaculture with special reference to shrimp culture. He suggested that model lay-outs of farms of different sizes may be prepared by CMFRI, CIFRI and Engineering wings in states.The need to co-ordinate activities for shrimp farming between the various Government departments like Revenue, Forest, Fisheries and Agriculture, Industry, Salt Department and MPEDA was also emphasised.

According to Shri V. Venkatesan, the main problem was lack of a suitable leasing policy of brackishwater areas, 50% of which falls under Government 'poramboke'. Fishermen being the actual users of the brackishwater, he pleaded that they should be given priority in allotting the areas for shrimp farming.

He preferred a minimum area of 5 ha and a lease period of 10 years. He stressed the need for the formation of a

Fish Farmers Development Agency, formation of a brackishwater farm engineering wing under the State Government, survey of seed resources and training of technical personnel.

Shri. P. S. Kumaradas, presented an account of the status, strategy and scope for commercial shrimp farming in Kerala. He said that suitable prawn farming projects might be drawn out for covering the entire 2,42,800 ha of brackishwater area of Kerala over a period of 20 Years. He emphasised the need for a well established extension service and financial assistance to prawn farmers in the private sector for starting commercially viable projects.

Dr. S. N. Dwivedi recommended six steps for utilising large area for brackishwater fish culture, namely selective stocking and rearing; establishment of seed collection and distribution centres; commercial production of prawn fry under controlled conditions; rearing of brackishwater prawn from seedlings to marketable size; prawn and fish culture in salt water and low cost simple technology for rural areas for farm construction, through fishermen.

He recommended that the entrepreneurs to go in for two crops along with chanos and mullets. He felt that the abundant prawn seed resources on the east cost could be utilised with advantage for culture and salt pan culture could be undertaken extensively as was done at Saphala salt pans.

Dr. T. A. Mammen called attention to various administrative aspects, viz. social, financial, organisational, legal and security aspects, that have to be solved before any large scale commercial shrimp farming could be undertaken in this country.

While considering social aspects, he said that the Planning Commission, while supporting the MPEDA's scheme for shrimp farming, impressed on the need for ensuring directly inducting fishermen. However as it is required huge capital investment and a certain level of technical expertise, he suggested initial development of water areas through agencies capable of high investment and possessing expertise in the management of such farm. He suggested that after an initial period of lease to such agencies, the developed farm should be given to fishermen. He also did not favour supporting the scheme on a subsidised basis.

Regarding organisational problems, he referred to the lack of basic infrastructural facilities for large scale farming and the need for making shrimp farming as a part of an Integrated Area Development Programme. The need for a massive national programme to produce / procure and supply of prawn seed were emphasised.

Considering legal problems with special reference to West Bengal, he said that Government's policy in regard to ceiling/ regulation of farm areas should be enunciated. As far as Kerala was concerned, the land utilisation act of 1967 needed amendment to include prawn also under "food crops". The immediate need for a working arrangement with the Agriculture and Irrigation Department, Forest Department was emphasised for developing shrimp farms.

The need for suitable administrative order/legislation to protect the interest of shrimp farmers against certain traditional fishing rights was also pointed out. The necessity for security mesures to protect the crop of prawn farmers against theft, which was fit for harvesting throughout the period of its culture, was also detailed. He referred to the problem of otter predation and need for some device to overcome this problem.

The Chairman made the following observations after presentations of papers.

1) Formulation of a national policy is easily said but there are many practical difficulties to spell out a clear policy.

2) Before going in for extensive shrimp farming, seed problem may be solved.

3) With the guidance of CMFRI and CIFRI the State Government could undertake extensive surveys of seed resources.

4) MPEDA should prepare project reports for finance from any of the financing agencies.

5) MPEDA may provide consultancy service free of charge.

6) The State Governments should undertake survey of areas suitable for shrimp farming, taking necessary guidance from MPEDA's 4 regional centres.

The Chairman recapitulated the main observations of speakers and declared the subject open for discussion.

Shri A. S. Shenoy, suggested regional committees for evolving national policies, for giving project reports etc. and a technical experts' committee as consultants.

Dr. V. G, Jhingran suggested that Government might set up farms with common facilities which could be subsequently given to rural poor to obviate the heavy burden of initial investment.

Shri T. V. Radhakrishnan, M/s. Shaw Wallace and Co., Madras, pointed out that fisheries may also be included under Credit Guarantee Corporation. Shri Dandekar, Director ARDC clarified that fisheries is already included under the same.

Shri Mhasawade, suggested that a survey team should be immediately selected and time bound programme given covering survey of varieties of shrimp available;area-wise, landing figures area-wise, seed resources, site selection for prawn farming land, site selection for demonstration farm at 4 to 5 places in each state. CMFRI and MPEDA should prepare and distribute key to juvenile identification. Fundamentals of farm engineering may be taught at CIFE and other fishery Institutions.

RECOMMENDATIONS

Seven papers were presented in the session and the following recommendations were made.

(1) A National policy should be formulated to develop shrimp farming/aquaculture.

(2) Extensive surveys may be conducted to select suitable areas for farming and to locate seed resources.

CMFRI, CIFRI and MPEDA may standardise procedure for such surveys and the surveys may be conducted by State Fisheries Departments under the guidance of MPEDA.

(3) There is immediate need for extension work covering all aspects of shrimp farming.

(4) MPEDA and State Fisheries Departments may take up demonstration and pilot farming as part of extension programme. State Governments should develop fishery engineering wings to specialise on construction of farms for shrimp culture.

(5) MPEDA may provide project proposals and feasibility reports.

(6) MPEDA may provide consultancy services free of cost.

(7) Area development is an important aspect for accelerated development of shrimp culture. Provision of common facilities may be made without passing on the cost to the entrepreneurs to help construction of shrimp farms.

(8) State Governments should formulate leasing policies if possible giving settlement rights to the farmer at the end of the lease period. 15 years may be the minimum lease period.

(9) Fishermen may be closely associated with farming programmes.

(10) There is need for a co-ordinated approach among Agriculture Department, Forest Department, Salt Department, Revenue Department and Fisheries Department to locate suitable areas for shrimp farming.

(11) Subsidy may be given on the capital cost of farm construction, at least in the initial stages to encourage investment.

(12) There is need for insurance cover against risk of cyclone.

(13) The trend of shrimp fishery should be monitored to suggest conservation measures.

(14) Suitable amendments to the land ceiling Act and land utilisation Act should be made to encourage shrimp farming.

(15) The MPEDA may be the lead organisation for all activities connected with commercial shrimp farming and extension work.

CONCLUDING SESSION – RECOMMENDATIONS

18-8-1978

Chairman	-	Shri S. Gopalan, I. A. S.
Rapporteur	-	Dr. V. D. Ramamurthy.

Shri S. Gopalan, Chairman briefly reviewed the summary of the discussions took place in the previous sessions and stressed the importance of prawn

farming and its role in augmenting marine products export as well as for food production. Then Shri P. J. Thomas, Hindustan Lever suggested out of his own field experiments, the most limiting factor of introducing prawn farming to-day is availability of brine shrimp which is limited in India. Growing brine shrimps should be taken up in salt pans in future by some agencies. While answering this Dr. U. K. Gopalan stated that brine shrimp is cultured and is readily available at NIO Headquarters, Goa and the same will be supplied on a formal request to Director, NIO, Panjim.

Dr. S. N. Dwivedi, Director, CIFE stated that an Institute for Brackishwater fish or prawn farming should be established by one of the centralised agencies in India. He has also urged high priority should be given to the issue. However, this has not been accepted by majority of the participants. Mr. G. N. Mitra stated for the time being there was no need for establishing any new Institute for brackishwater fish farming.

Finally winding up the Session the Chairman stated one of the reasons for the slow progress of prawn culture industry was the scarce flow of finance and hesitation to invest and promote enterprise due to lack of information on the economic viability of the culture operation. It is well known that the economics of prawn culture depends on location, fry resources, finance and technical know-how and co-operation from State Government etc. All efforts are being made by MPEDA to demonstrate techno-economic feasibility of prawn farming through a number of demonstration projects at different centres.

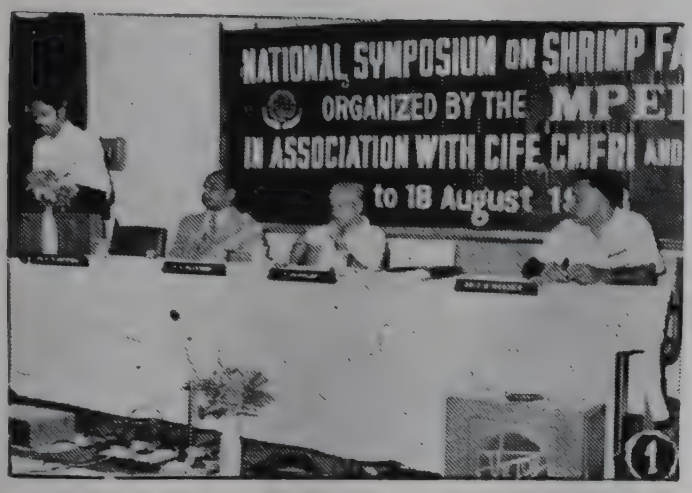
Recommendation of the concluding session

1. The symposium having been an occasion for presentation of information available on shrimp farming, the papers presented at the symposium should be edited and published along with the proceedings.

2. The next symposium on shrimp farming should be held in August,1981. The final session came to an end with a vote of thanks by Dr. T. A. Mammen, Director, MPEDA.

Plate-I

Plate-II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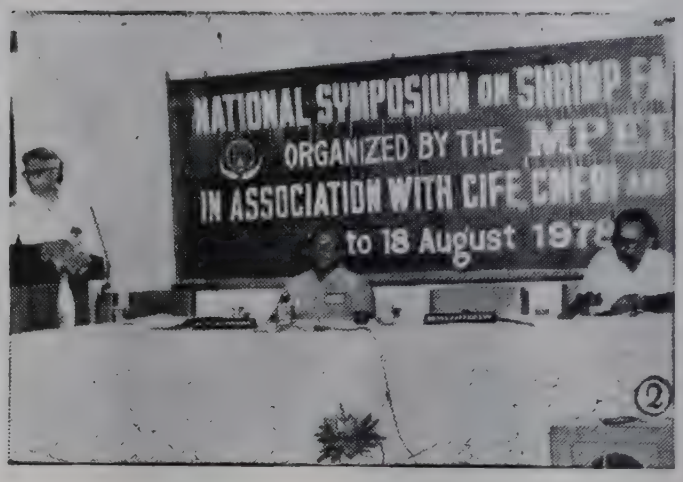
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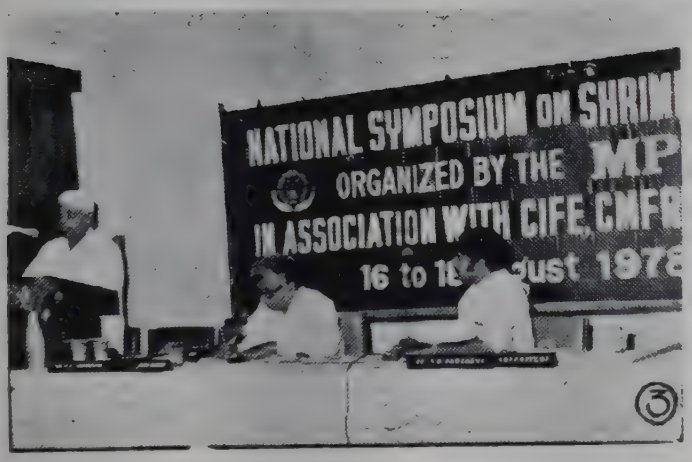
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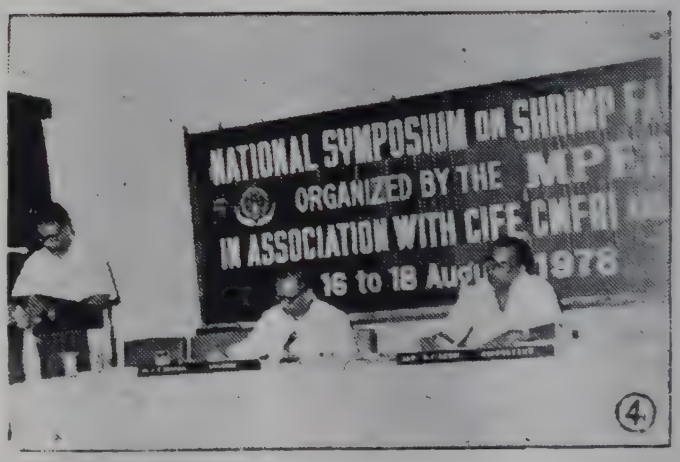
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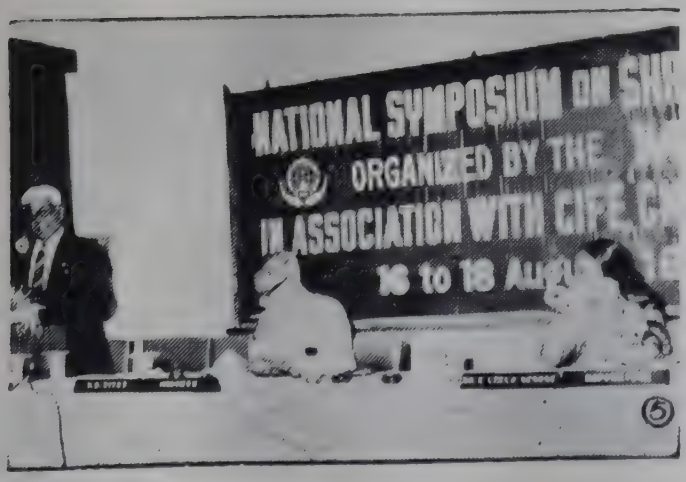
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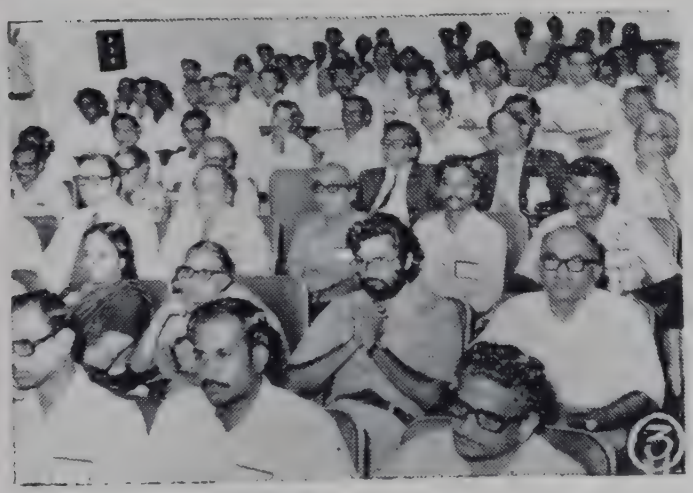

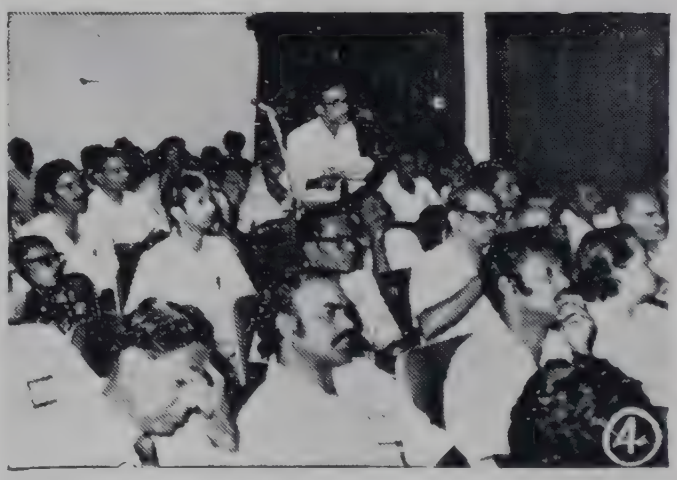

PLATE I

1. Mr. P. R. S. Thampi - Read the inaugural address on behalf of Dr. M. S. Swaminathan.
2. Mr. K. H. Alikunhi - Delivered the key-note address
3. Mr. S. Gopalan - Presided the inaugural session
4. Dr. T. A Mammen - Welcomed the participants
5. Mr. K. Chidambaram - Presented a paper
6. Mr. G. N. Mitra - Chairman for Technical Session IV
7. Dr. S. N. Dwivedi - Chairman for Technical Session III
8. Dr. E. G. Silas - Chairman for Technical Session I
9. Dr. V. G. Jhingran - Chairman for Technical Session II

PLATE II

1. Inaugural Session - Mr. S. Gopalan, giving the presidential address. Sitting from left to right-Dr. S. N. Dwivedi, Mr. K. H. Alikunhi and Dr. T. A. Mammen.
2. Technical Session - I - Chairman, Dr. E. G. Silas, Rapporteur, Mr. M. S. Muthu and Mr. G. N. Mitra participating in the discussion.
3. Technical Session - II Chairman, Dr. V. G. Jhingran, Rapporteur, Dr. P. U. Verghese and Mr. K. Chidambaram participating in the discussion.
4. Technical Session - III - Chairman, Dr. S. N. Dwivedi, Rapporteur, Mr. D. V. Reddi and Dr. T. A. Mammen presenting a paper.
5. Technical Session - IV - Chairman, Mr. G. N. Mitra, Rapporteur, Dr. (Mrs) E. Leela George and Mr. Chidambaram presenting a paper.
6. Concluding Session - Chairman, Mr. S. Gopalan and Rapporteur, Dr. V. D. Ramamurthy.

PLATE III

1-6

Photographs taken inside the CIFE Auditorium showing delegates attending the Symposium.

ROLE OF HATCHERIES IN COMMERCIAL FARMING OF PENAEID SHRIMPS

K. H. ALIKUNHI

Almanar, Eriyadu, Kodungalloor, Kerala

Introduction

In the context of ever-increasing demand for export of shrimps, attention, of late, is naturally being focussed on possibilities of large-scale, commercial culture of fast growing species of marine as well as freshwater shrimps, in several countries, including India. Marine and fresh water species suitable for culture are widely distributed and their young ones occur in natural habitats, during certain seasons, in varying abundance.In countries like Philippines, Indonesia and Taiwan collection of young ones of the tiger shrimp, *P.monodon* from natural habitats is an organised industry, as is the case with the milkfish *(Chanos chanos)* fry. Though hundreds of millions of shrimp post-larvae and juveniles are collected every year from these sources, these generally meet the seed requirements of small-scale culturists only. Large-scale farming operations require,at a time,enormous numbers of post-larvae and juveniles and collectors generally find it difficult to accumulate such large stocks for supply. Further, prolonged storage of collected larvae often results in heavy mortality also. Artificial breeding and successful larval rearing of *P. japonicus* by Hudinaga (1942) in Japan and of *Macrobrachium rosenbergii* by Ling (1969) in Malayasia have been the first major break-through enabling large-scale seed production and culture of these species. Concentrated work during the last three decades has resulted in highly specialised technology of controlled breeding of penaeid shrimps and successful mass rearing of larvae in hatcheries. Attempts are being made in several countries in south-east Asia, notably in Taiwan,Philippines, Thailand, Indonesia and Malayasia to adopt these techniques for commercial production of shrimp seed. In India, we have yet to make a beginning in this direction. Recent work reported from the Central Institute of Fisheries Education, Bombay on *P. merguiensis* and *M. affinis* and from the Central Inland Fisheries Research Institute, Barrackpore on *M. rosenbergii* indicate that controlled breeding of shrimps and successful mass rearing of larvae could easily be organised in India also, if proper hatchery facilities are provided.

Natural Seed resources

The major cultivable species of penaeid shrimps in Indian waters are *P. monodon, P. merguiensis* and *P. indicus.* Among fresh water species *M. rosenbergii* and *M.malcolmsonii* are important. Though *P. monodon* is widely

distributed, marine landings indicate that *P. merguiensis* and *P. indicus* are far more abundant than *P. monodon*. Seed survey carried out by the Central Inland Fisheries Research Institute also show that post-larval abundance of *P. monodon* is very much less than that of either *P. merguiensis* or *P. indicus*. During peak periods of post-larval ingress, *P. indicus* constituted 80-90% of the collections (Das, 1978). Das further estimates that upto 10,000 post-larvae of *P. monodon* can be segregated per tide per day. During April, 1977 the Central Inland Fisheries Research Institute found it possible to segregate 32,000 post-larvae of *P. monodon* in 90 man-hours. Quantitative estimates of post-larval and juvenile abundance of other species are lacking. While natural seed abundance generally fluctuates from season to season and from centre to centre, the information presently available clearly indicate possibilities for organising systematic collection of prawn seed from natural sources as an industry. This would be the first step in encouraging shrimp farming, as seed could then be made available to interested shrimp farmers.

Controlled breeding

As stated earlier, the inherent bottlenecks of uncertain supplies, non-uniform size, mixture of species, prolonged storage etc. necessitate controlled breeding of desired species to ensure adequate supply of quality seed. The marine prawns mature in the sea and gravid females with spermatophores implanted in thelycum,are picked out alive from short-duration trawl hauls, kept in running sea water on deck and conveniently brought to the hatchery. They are released in prepared spawning tanks with clean, fresh, filtered seawater (salinity ranging from 28 to 34 ppt) and provided with artificial aeration at several points. If the spawners are ripe, they spawn overnight and the eggs hatch out into nauplii within 12-14 hours. The spent spawners are removed; water level increased to about 60-70 cm depth and within the next 36-42 hours, the nauplius at its sixth moult metamorphoses into the zoea. Based on the population of larvae in the culture tank a careful programme of feeding is now initiated, and the zoea at its third moult (in 3-4 days) transforms into the mysis stage. Feeding adjusted to the increased size of larvae and prevailing population density continues and water is partially renewed daily. *Artemia* nauplii constitute the main food at this stage and within 3–4 days the mysis moults into the first postlarval stage 9 to 10 days after the eggs hatched into the nauplii. Keeping the post–larvae in the hatchery tank for another four days on a proper regime of feeding in which *Artemia* nauplii continue to be a major item, they could be harvested on the fifth day and transferred to prepared nurseries for rearing.

With extremely high density of larvae in the hatchery tanks (starting nauplii population ranging from 50 to 100 per litre of water) maintenance of hygiene and proper feeding assume extreme importance. Production of diatoms in the culture medium itself, by judicious application of inorganic fertilizers meets food requirements during early larval stages. For later stages, besides

arrangements for satisfactory hatching of *Artemia* eggs and sustained supply of nauplii, elaborate systems of mass culture of other larval feed organisms like rotifers (Branchionus spp) and waterfleas (Moina spp.) have been developed. Non-availability of dependable stocks of *Artemia* eggs in adequate quantities and high costs are limiting factors in the expansion of shrimp culture in south-east Asia including India.

Induced maturation and spawning of penaeid shrimps

Collection of shrimp spawners from the sea is not too difficult during peak seasons of spawning but during other seasons, including monsoon months, it is extremely difficult to obtain spawners. In this context, recent studies on successful induction of gonadial maturation and spawning in pond reared stocks of major species of penaeid prawns, including *P. mondon*, *P. merguiensis* and *P. indicus* assume great significance and point to a technique for obtaining spawners throughout the year (Alikunhi *et al.*, 1975.)

By careful ablation/cauterisation of eyestalks and holding the operated prawns in captivity, in cement tanks/plastic pools, under very favourable environmental conditions (food in particular), rapid gonadial maturation is induced; *P. mondon*, attaining full ovarian maturity within 25–30 days after the operation (Alikunhi et al; op. cit). In the case of *P. merguiensis* and *P. indicus* the maturation process is much more rapid, taking only 5 to 7 days after operation.Those artificially matured specimens spawn viable eggs which on hatching yield active nauplii that could be successfully reared in the same manner as larvae from spawners from the sea. Concerted work now in progress, on this aspect, in several countries is bound to result in a dependable, simple, field technique for production of shrimp spawners in the farm itself. This, in turn, will lead to a degree of genetic selection of brood stocks. Since the operated females, after moulting, having been found to have been impregnated afresh, there are possibilities of not only selective breeding, but also hybridisation between selected species.

Mass rearing of larvae on artificial feed.

Consequent to difficulties in getting *Artemia* cysts and in developing elaborate systems for bulk production of live larval feed organisms, several types of artificial feeds have been tried, alone or in combination with conventional live feed, mainly during mysis and post-larval stages.There does not appear on record a complete, successful artificial food for the entire larval phase of penaeid shrimps. In this context, the recent work reported by Hamid Ali (1978) and Hamid Ali and Dwivedi (1978) is of significance, particularly in countries where *Artemia* cysts are difficult to obtain. *Acetes* spp. which they have successfully used as feed in mass cultures of larvae of *P. merguiensis*, *Penaeus* sp., *M. monoceros*, *M.affinis* and *M.brevicornis* are available in plenty along the Indian coast and is comparatively very cheap.

With possibilities of induction of maturation and spawning in pond grown stocks and with a dependable artificial feed for larval rearing, mass production of penaeid larvae in hatcheries in India should not present serious problems.

Model hatchery

Besides adequate technical expertise, primary considerations for locating a hatchery are optimum water quality and availability of spawners throughout the year. Since possibilities of producing spawners in farm ponds have been reported, availability of clear seawater of salinity, 28 to 34 ppt, throughout the year assumes greater significance. A source of freshwater supply is also essential for the hatchery to enable necessary adjustments in water salinity.

Though extensive laboratory work has been carried out in several institutions to complete studies on larval history of several species of penaeid shrimps, hardly any attempt has been made in India at mass rearing of penaeid larvae, except for the pilot studies organised by the Central Marine Fisheries Research Institute at Narakkal and the few large-scale trials organised at the Central Institute of Fisheries Education at Bombay. In this context detailed considerations on establishment of commercial shrimp hatcheries become pertinent. A lay-out of 12 hatchery tanks of 18 to 60 tons capacity capable of producing about 100 million post-larvae per year (assuming that only 10 batches of larvae will be reared in each tank in a year) is shown in Fig. 1.

The tanks will be of cement concrete construction; 1.5 metres deep, bottom regularly sloping towards the outlet which is provided with controllable valves and opens into the harvest basin. The tanks should be under a protective shed, open at sides and the roofing, in places, provided with glass tiles to permit adequate lighting. Each tank will have saltwater, freshwater and air supply connections. The major items of equipments and supplies required for the operation of the hatchery are listed in table 1.

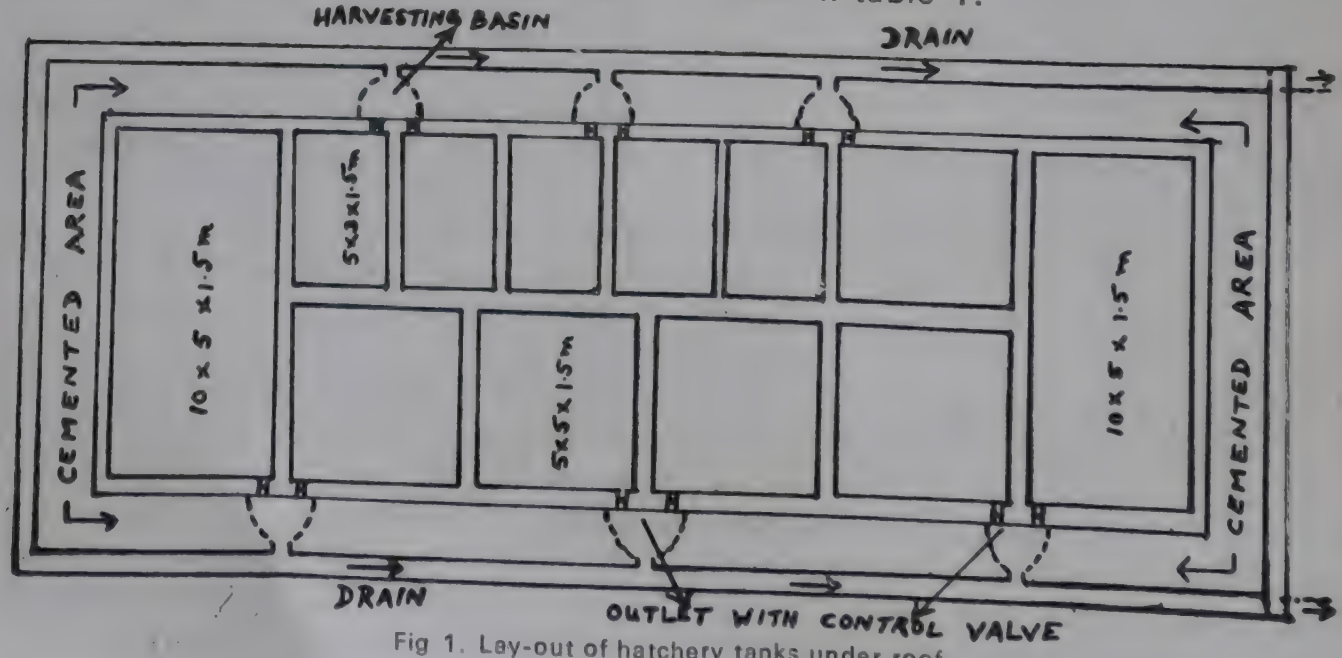

Fig 1. Lay-out of hatchery tanks under roof

TABLE-I

Major equipments and supplies at a shrimp hatchery

(Capacity: About 10 million post-larvae/crop)

No.	Item	No/Quantity
1.	Air Blowers; capacity 3 cu.m. or above/ minute; in 3m depth.	2
2.	Power generator; of sufficient capacity to run all machinery at the hatchery	2
3.	Sea water pump; 10 & 5 HP capacity	1 each
4.	Small pumps; 1 HP capacity	2
5.	Seawater filtration unit.	2
6.	Overhead storage tanks for seawater and freshwater	1 each
7.	Two room laboratory for larval examination and feed storage/preparation.	
8.	Suitable housing for blowers, generators and pumps.	
9.	Plastic pools for live larval feed culture: 3' x 2' : 6; 6' x 4' : 6; 12' x 4': 6; 15' x 4' :4.	
10.	PVC pipes and fittings for above items	As required
11.	Air stones, nozzles, valves, tubing and other fittings for air supply.	As required
12.	PVC siphons, filter boxes, nylon screen netting of various mesh.	As required
13.	Battery operated aerators, buckets, tubes, etc. for spawner transport.	As requirep
14.	Cauterising unit.	1
15.	Salinity refractometer, thermometers, beakers; other glassware.	As required
16.	Microscope for larval examination	1
17.	Refrigerator	1
18.	Freezer, box type, 1 ton capacity	1
19.	Gas stove and fittings.	1 Unit
20.	Aluminium vessels; assorted	4
21.	Electric blender	2
22.	Stainless steel sieves.	1 set
23.	Weighing balance; accuracy: 0.1 g.	1

Extra tanks/pools have to be provided at the hatchery premises to take up mass culture of live, larval feed organisms such as rotifiers and waterfleas. Since very successful larval cultures have been shown to be practicable with artificial feeding alone (Hameed Ali, op, cit.) necessary facilities are to be provided for storage and processing of larval feed. Under our prevailing conditions, in a successful culture, the nauplii, in 9-10 days' time will reach the first post-larval stage. At post-larval stage V they could be harvested from the hatchery tank and transferred to prepared nursery ponds for further rearing.

In successful larval cultures, stocking density at Nauplius stage will be around 100 per litre and at first post larval stage a survival of 40 to 50 per litre could be expected. Considering their recorded fecundity, and assuming on an average 80% spawning success and 80% fertilization and hatching of laid eggs, the number of spawners of average size required for producing one million juveniles of 25-30 mm length could be roughly estimated as follows:

Species	*No. of medium size spawners required to produce 1 million juveniles.*
P. monodon	8 or 9
P. merguiensis	18
P. indicus	18

With greater experience in larval rearing technology the number of spawners required could be significantly reduced. Considering the seasonal availability of spawners, the target of production and the number of spawners required, hatchery operations could be planned in advance to achieve the target.

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INDUCTION OF MATURATION AND SPAWNING IN POND-GROWN STOCKS OF PENAEID SHRIMPS FOR LARGE-SCALE SEED PRODUCTION

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Abstract

Controlled breeding of penaeid prawns, based on gravid female spawners collected from the sea is subjected to serious fluctuations depending on the breeding season of the species and availability of spawners. To ensure planned, year-round production of stocking material, spawners should be available throughout the year. The first successful attempts at induction of gonadial maturation and spawning in pond grown stocks of penaeid shrimps was reported by Alikunhi *et.al.*, in 1975. Continued work carried out during 1977 at the Brackishwater Aquaculture Development Centre, Jepara, Indonesia, revealed that;

i) by cauterisation of eye-stalks mortality during operation could be reduced to almost nil in *P. monodon P. indicus* and *P. merguiensis*

ii) by providing ideal water conditions and adequate food it was possible to produce several gravid female spawners of each species, at any given time. to enable large-scale spawning operations being organised.

iii) in the case of *P. monodon*, pond stocks of males and females are immature and males have to be operated 10-15 days in advance of the females, to enable them attain gonadial maturity and impregnate the immature, operated females, subsequently released with them. Almost 90-100% of the operated, developing females were impregnated by the artificially matured males.

iv) operated female specimens of *P. monodon* attained rapid gonadial maturation and could be spawned exactly 15 days after eye-stalks cauterisation. After one spawning, the female matured again within 10-15 days and got impregnated afresh, provided the environment was well managed.

v) operated mature males of *P. monodon* impregnated operated, developing females of other species like *P. merguiensis* when released together in the same tank.

vi) operated female *P. merguiensis* matured and spawned within 4-5 days after the operation.

vii) *P. indicus* appears to be as hardy

as *P. monodon* operated females taking only 6-7 days to attain maturity. Often 100% of the operated females became gravid. Resorption of ovaries was rapid if spawning did not occur. Rematuration was also equally rapid.

viii) artificially matured specimen on spawning, produced viable egg which on hatching produced health nauplii that could be reared successfully as the larvae fro spawners.

SEMI-COMMERCIAL HATCHERY FOR LARGE SCALE REARING OF PENAEID PRAWN LARVAE

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Abstract

Successful rearing of penaeid larvae using *Acetes Sp.* as artificial feed, carried out in Indonesia has reported by Hameed Ali (1978). Similar larvae rearing was undertaken at the C. I. F. E. where owing to its location, fresh area water is not available. Rearing experiments were carried out in 2.5 tons to 9 tons plastic pools using.

1) Sea water transported by trucks to the Institute.

2) Tidal creek water contaminated by organic matter and dark green in colour was pumped into large tanks and allowed to settle for 7 to 8 days and (3) Brackish water from a deep tube well mixed with, pumped in the settled creek water.

Spawners of *P. merguiensis*, *M. affinis* and *M. brevicornis* were obtained from the sea picked out from trawl hauls. During the period 28-1-78 to 21-6-78 larvae cultures were successfully reared as in table I.

In four cultures 1,237,052 nauplii were raised producing 646,604, post-larvae I. This represents on an average 52.3% survival. Production averaged 37,835 postlarvae-I per cubic meter of water.

In cultures 1 and 3 *Acetes Sp:*, in culture No.2 mysids and in culture No.4 *Acetes* and *Branchiones* combined were fed. *Acetes* and mysids were processed as already reported.

Hatchery management practices are the important highlights of this programme. This involved conditioning and use of brackishwater, daily partial replenishment of water which checked pollution of the water and making available

TABLE-I

Species	No. of spawners	No. of nauplii	No. of postlarvae I produced	Survival %	Postlarvae production No./cu. m.
1. *M. brevicornis*	4	259590	4580	1.76	1800
2. *M. affinis*	2	300783	251924	83.8	41860
3. *P. merguiensis*	1	351164	251160	71.5	98988
4. *P. merguiensis*	1	325516	138940	42.7	23157

different kinds of feeds including a particular suspension of *Acetes* mysids and live *Branchionus*. The aeration and water change systems were adopted to meet local conditions. The hatchery facilities are all locally fabricated and can be set up at any desired location where water of suitable salinity is available.

Prawn larvae rearing has been successfully carried out in a few countries particularly Galveston (USA) and Japan. There cost for raising one million and two hundred thousand larvae is US $ 18,977 and US $ 27,810 respectively. The cost of raising the same number of larvae based on the present experiments at C. I. F. E. is US $ 3170 (Rs. 25,300/-) Thus this work marks a first step in the setting up of semi commercial hatcheries in India.

PRELIMINARY EXPERIMENTS ON MASS REARING OF PENAEID LARVAE ON CHEAP ARTIFICIAL FEEDS

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Abstract

The experimental work reported in his paper was carried out at the Brackish Water Aquaculture Development Centre Jepara, Indonesia, during June-September, 1977.

At present penaeid larvae culture is almost entirely dependant on diatoms as feed for zoea and *Artemia* nauplii as feed for the mysis and postlarval stages. When these natural feeds become scarce artificial feeding with soyabean and curd, powdered fat free ricebran, marine yeast, artificially produced activated sludge etc. have been attempted with varying success. However, no reports could be found of the rearing of penaeid larvae to the postlarvae stage using only artificial feeds processed from fresh tissue.

Hence, in the context of inadequate and undependable supply of *artemia* cysts and inherent difficulties in developing intricate methods of mass culture of live, larval feed organisms, mass rearing of larvae of *Penaeus merguiensis*, *Penaeus Sp.* and *Metapenaeus monoceros* was successfully carried out in 2 to 9 ton hatchery pools by feeding them with suitably processed, non-penaeid shrimps *Acetes sp.*, and mysids *Mesopodopsis sp.* Blended feed was sieved through 50-160 micron mesh sieves for mysis and administered at 5 hourly intervals at approximately 2-3 times the weight of larvae, per day. In six cultures utilising 1,340,708 nauplii, 573,690 survived to first post-larvae stage, representing an over all survival of 42.8%. Survival ranged in individual cultures from 8.62% to 97.16%. Production ranged from 11,759 to 57,308 per cubic meter of water with an average of 32,115 per cubic meter.

The present results were compared to records available of cultures conducted in Japan and Taiwan. Using the conventional method show that they are better in both survival and production per cubic meter, as shown below:

Country	Total No. upto reared	Total P1. produced	Survival %	Production per cubic meter
TAIWAN	750299	64934	8.65	21644
JAPAN	31433000	12820000	40.78	12000
INDONESIA	1340708	573690	42.8	38894

BREEDING OF *PENAEUS MONODON* IN FARM POND UNDER CAPTIVITY

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Introduction

The Jumbo Tiger prawn, *Penaeus monodon*, Fabricius, is one of the largest and fast growing penaeid, cultivated in the Indo-Pacific region. Culture of this species depends on the collections of post larvae and juveniles from tidal estuaries, creeks and intertidal pits, for stocking. With the increasing emphasis on the development of estuarine saline swamps for prawn farming the natural source of seed may not be sufficient to supply the increasing demand. Artificial propagation of the prawn in brackishwater conditions will solve this problem to a great extent. However, this species is never observed to mature, naturally in Brackishwater pond conditions. The present communication reviews the work done in the field of artificial maturation and breeding of prawns with a note on the recent success of maturing and breeding of *P. monodon* in brackishwater conditions under captivity at Bakkhali Fish Farm of Central Inland Fisheries Research Institute, Barrackpore, West Bengal.

Induction of Maturity.

In case of *P. monodon*, Alikunhi *et. al.*, (1975) reported that, whatever be the size, both males and females are sexually immature in brackishwater ponds and the males have to be brought upto maturity to enable them impregnate the females. Contrary to this observation, Halder (1977 MS) observed that all the males above 60 gms are fully mature in brackishwater conditions. The degree of maturity of female and male *P. monodon* may be determined by looking through the carapace or exoskeleton and at the base of the fifth walking leg respectively. In case of the matured male, conspicuous, whitish spermatophores can be seen near the gonophores at the base of the fifth walking leg. In female the stage of maturity can be determined from the fullness and colour of the ovary, as seen through the exoskeleton.

Maturation and Breeding of *P. monodon*

Eye-stalk ablation and its effects:

In crustaceans, the development of gonads is controlled or inhibited by certain hormonal secretions produced by glands situated in the eye-stalks and stored in the sinus gland located close to cornea (Waterman. 1960; Green, 1967; Carlisle and Knowless, 1959). Extensive work on induction of gonadal

maturity by eye-stalk extirpations has been carried out in decapods (Kaestner, 1970). Mostly followed method of ablation is that described by Liao and Huang (1972). An incision is made just at the middle of the eye ball with a sharp blade. Then the eye ball is emptied of its content, by applying progressive pressure between the right thumb and the fore finger at the distal part of the eye-stalk finally, crushing the whole eye-stalk. Alikunhi *et. al.*, (1975) observed that the ablation of one eye-stalk alone did not have any visible effect on development of ovaries. Halder (1977MS) observed that unilaterally ablated prawns, started exploring the surroundings for food 27 minutes after ablation, but bilaterally ablated prawns didn't accept food during their 45 minutes stay in the fibre glass tank, before releasing into cages. Santiago *et. al.* (1976) observed that bilateral ablation drastically affected the behaviour and balance of the prawns, resulting in high mortality, and unilateral ablation was sufficient to induce maturation and spawning.

It takes 20 to 30 days for larger males to mature from the day of ablation and females also take 20 to 30 days for full maturation irrespective of their size and age (Alikunhi *et. al.*, (1975). Primavera (1977) reported that complete maturation and spawning took place in few females within 12 days of ablation and the development of ovaries seems to take three weeks after ablation, in most of the females. Halder (in press) achieved full maturation and breeding within 40 days of ablation.

Experiment conducted at Central Inland Fisheries Research Institute.

Eighteen immature specimens of *Penaeus monodon* (7 females and 11 males) ranging in total length 195-218 mm; body weight 70-95 gm and total length 177 to 202 mm, body weight 50-78 gms respectively were selected from culture ponds in which the salinity varied between traces and 1 ppt. The specimens were acclimatized gradually to 15 ppt salinity in a plastic container before they were transferred to the nylon net cages fixed in a 0.02 ha pond with 2 m deep water column at 15 ppt salinity and water temperature 22.4° C on January 23, 1978. On January 26, 1978, the specimens were unilaterally ablated, following the method of Liao and Huang (1972). During the period of experimentation, the ambient salinity of the experimental pond water was gradually raised to 25 ppt by drawing the high salinity water from the adjacent salt water creek.

Experimental specimens in the nylon net cages were fed throughout, with minced fresh prawn and trash fish at the rate of 10% of the initial weight of the specimens and were observed for progressive maturity stages. Observations on maturation of 7 females are presented in table 1.

TABLE - I

Maturity of female *P. monodon* after eye-stalk ablation

(from Halder, in press)

Sampling Dates	Stages				
	S_0 (No. of days)	S_1 (No. of days)	S_2 (No. of days)	S_3 (No. of days)	S_4 (No. of days)
2.2.1978	7 (8)*				
9.2.1978	-	6 (15)			
16.2.1978	-	-	5 (22)		
23.2.1978	-	-	3 (29)	3 (29)	
4.3.1978	-	-	-	3 (38)	3 (38)

* Number mentioned within brackets indicate the number of days from the date of ablation and those without brackets show the number of specimens.

At the end of 38 days on March 4, 1978 3 females specimens were found to be fully mature. To ensure continuous flow of water and aeration, the mature females (total length 200-218mm body weight 85-95 g) were transferred to a nylon net cage of 0.1 mm mesh, protected with split bamboo mat enclosure and fixed in an open creek, adjacent to the farm,with 25 ppt salinity with water temperature of 26.4 °C. Feeding the specimens were continued as before. On March 6, the three specimens were examined and it was found that 2 of the 3 females were completely spent and the third specimen has spawned partially. Innumerable nauplii were observed when the ambient water in the cage was filtered through a plankton net.

Conclusion

The success in maturing and breeding of *P. monodon* in brackishwater conditions will have a great impact on brackishwater farming. Since the occurrence of *P.monodon* post larvae in nature is seasonal and their abundance is location specific culture of this species is not possible in many coastal states,

due to their non-availability. Once this maturation, breeding and hatchery management is established, culturing of this highly priced prawn would not pose any difficulty.

Acknowledgement

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PRELIMINARY INVESTIGATIONS ON THE REARING OF POSTLARVAL STAGES OF *PENAEUS MERGUIENSIS* ON *MYSIDS* TO STOCKABLE STAGE

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Abstract

The nutritional requirement of prawns and shrimps has created immense biological interest because of their food value. The success of shrimp farm depends upon the supply of suitable food to the developing individuals. Along the Maharashtra coast, *Mysids* familiarly called 'Lepha' occur abundantly and are sold by the fisherman at a low price. Hence, an attempt was made to culture postlarvae of *Penaeus merguiensis* on *Mysids* to stockable size.

Postlarvae of *Penaeus merguiensis* weighing 34.30 mg (body length: 22.0 mm) were reared on *Mysids* at 35‰ S for 30 days and their food intake, growth and conversion efficiency (K_1 : %) were determined. On an average, the postlarvae consumed 172.20 mg *Mysids*/larvae/day. During the 30 days feeding period, the postlarvae exhibited a growth rate of 6.07 mg/larvae/day. In body length, the individuals attained a size of 39·33mm. The efficiency of food conversion amounted to 3.55%. Thus the 'house keeping' of postlarvae of *P. merguiensis* may be established. In 50 days, 1 kg of initially stocked postlarvae in the weight range of 34.30 mg requires 22.25 kg of *mysids* to produce 10.85 kg of new juvenile flesh.

PRAWN FRY RESOURCES IN THE KAYAMKULAM LAKE

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1. Introduction

Commercial culture of prawns is practised in India mainly in the paddy fields of Kerala (George *et al* 1968) and in the salt water 'bheris' of Sunderbans in West Bengal (Hora and Nair, 1944). The young ones of different species of marine prawns such as *Penaeus indicus*, *P. monodon*, *P. semisulcatus*, *Metapenaeus monoceros*, *M. dobsoni*, *M. affinis and M. brevicornis* brought in by tidal currents are trapped and cultured in these enclosures. About 4500 ha. of fields are utilised at present for prawn culture in Kerala.

Hoevwer, Prawn culture faces the following limitations:

(1) the availability of prawn fry of fast growing and adaptable species

(2) location of the farm or pond in relation to the coast and estuary.

(3) transportation of the seedlings to the farm area.

There are mainly two methods to obtain prawn fry for culture purpose. They are (1) to rear the prawn larvae in the laboratory, (2) to collect them directly from backwaters and estuaries. Considering the above two methods, the second one is preferable and it is less expensive especially in places where the larvae and juveniles are available in plenty in the natural surroundings. The present paper is intended to supply information on the prawn resources in Kayamkulam lake in Kerala, which is a narrow stretch of backwater lying between 9° 2' and 9° 16' N latitude and 76° 26' and 76° 32' longitude having an approximate area of 50 sq. km. This backwater has the peculiarity of developing a sand bar at the mouth during the summer period for about 3 to 4 months, thereby cut off from the sea till the south west monsoon is in full swing in June-July.

2. Materials and Methods

Ten stations were chosen to collect samples in the lake in the vicinity of 2 km around Kayamkulan barmouth. The period of investigation was from June 1976 to May 1977. A 50 cm diameter organdie net (.33 mm mesh size) was used for collecting the prawn fry along with other plankton. Regular collections were made twice in a month in day and night during low tide and high tide. Duration of each haul was 15 minutes and the net was operated from a moving canoe. Occasional collections were also made from other localities to supply additional information. Two sets of samples were collected during each time, one set for data collection and the other set

for survival studies. Immediately after collection the first set was preserved in 5% formalin for further studies on larval abundance and the second set was transferred into large buckets having water taken from the same area. From the bucket, the shrimp fry were scooped out using another coarse meshed cotton net (.5 mm mesh size) into another bucket having salt water taken from the same area. The buckets were properly covered with a wire gauze to prevent jumping of fry out of the bucket. The water in the bucket was aerated by stirring or using an aerator.

3. Results

Survival of post larvae. About 100 numbers of post larvae were put in one bucket having a capacity of 15 l. For the first one hour no further aeration was needed. During this time mortality rate was high, being about 12%. After that the water was aerated occasionally using an aerator. For the first six hours no food was given. During this time mortality rate came down to about 8%.

After 6 hours, postlarvae and early juveniles were fed with chopped clam meat, pieces of annelids and cooked fish flesh. Small quantities of food were given to prevent fouling of water. After 24 hours water was changed. The salinity of the water used was of the salinity 15‰ to 25‰. The survival rate in confinement after 24 hours was 78%. After 24 hours the mortality of prawn fry diminished to 2 to 5%.

Studies on occurrence and abundance. Analysis of the preserved specimens in the laboratory have shown that the sorted sample constituted the post-larvae and early juveniles of the following species in the order of their predominance in the area.

1. *Penaeus indicus*
2. *Metapenaeus dobsoni*
3. *Metapenaeus monoceros*
4. *Penaeus monodon*

A key for the identification of the post larvae of the four species is given by Mohamed and George (1968).

Of the total number of post larvae collected in an year from Kayamkulam lake *P. indicus* constituted 50.1%, *M. dobsoni* 41.9%, *M. monoceros* 4.5% and others including *P. monodon* 3.5%. From the above data it is obvious that *P. indicus* is predominant in the collections and this species can easily be collected for culture purpose. This species has a moderately fast growth rate, the rate being 13 mm in 4 weeks.

The fry of *P. indicus* can be easily distinguished by naked eye from other species by the presence of reddish brown chromatophores at the distal end of the tail fan and telson and also by the large size of the eyes with long eye stalks.

In the Kayamkulam lake postlarvae of *P. indicus* occurs throughout the year, the peak period being October to January with a maximum in December. They are poorly represented in the collections during April to July. During the peak period of occurrence an average of 161 number of fry of *Penaeus indicus* above 0.5 mm total length per haul was

obtained.

The size of the postlarvae of *P. indicus* obtained from the lake ranged from 5 mm to 22 mm in total length. As the Table 1 shows the size group having a total length of 11-16 mm were predominant in the collections during November and December and those belonging to the group 17-22 mm size were dominant during January and February.

TABLE I

Occurrence of different size groups of post larvae of *Penaeus indicus* per haul in Kayamkulam Lake during 1976-77

Length range (mm)	1976					1977					
	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
5-10	7	5	6	15	57	81	49	31	9	28	6	-
11-16	14	3	12	31	36	93	128	14	16	15	20	9
17-22	4	3	8	12	20	23	65	58	32	5	-	5

Factors influencing the occurrence of prawn fry. Observations have shown that the prawn fry prefer shallow areas between a depth range $\frac{1}{2}$ to 3 m. Also they were abundant in shallow puddles and under the shade of mangroves where there is least disturbance and large number of post larvae could be collected during day using hand nets. During December-February period from these shallow regions upto 3000 fry could be collected by a single person within an hour.

The Table 2 shows that generally the number of larvae was higher at high tide than at low tide.

TABLE-II

Average number of post larvae of *P. indicus* per haul* in Kayamkulam Lake during 1976-77

Time of collection	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
low tide	10	3	8	18	45	91	111	40	28	18	11	7
high tide	17	8	18	40	58	106	131	63	29	30	15	7
Full moon fortnight	12	5	11	26	44	82	105	35	25	21	9	9
New moon fortnight	15	6	15	32	59	115	137	68	32	27	17	5
Day	11	4	6	13	22	42	58	41	17	16	10	3
Night	16	7	20	45	81	155	184	62	40	32	16	11

* Each haul is for 15 minutes using 50 cms diameter plankton net.

The number of postlarvae for the bright and dark halves of the month were taken separately and the results (Table II) show that collections during the new moon fortnight were richer than during the full moon fortnight. It was also observed that both on new moon and full moon days and on 2 days before and after prawn fry were abundant in the estuarine catches.

The day and night collections using plankton net were analysed separately and the results (Table II) show that the postlarvae are more abundant at night than in day collections. The most suitable time for the collection of postlarvae and early juveniles were found to be from 6 pm to 8 pm and from 4 am to 6 am.

4. Discussion and Conclusions

The results of the field collections of prawn fry carried out in the Kayamkulam lake and later studies in the laboratory have revealed the following facts.

1) Post larvae and early juveniles of Penaeid prawns are abundant in the area and could be collected using plankton net and hand net.

2) Of the four species ie. *P. indicus*, *M. dobsoni*, *M. monoceros* and *P. monodon* found in the area, *Penaeus indicus* is predominant constituting more than 50%.

3) The fry of penaeid prawns of size 5-22 mm were common/abundant from October to January

4) The average number of *Penaeus indicus* obtained was 161 per 15 minutes' haul against the tidal current and much more in the shallow sheltered areas. The post larvae were most abundant during high tide at night particularly during the full moon and new moon days.

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A SURVEY OF NATURAL COMMUNITIES OF JUVENILES OF THE PENAEID PRAWNS

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Introduction:

The prawn fishery ranks among the most valuable and important fisheries of India with a very good potential for expansion. Its total annual production was 1,16,270 tonnes in 1976 (C. M. F. R. I., 1977) being 8.34% of the total commercial fisheries. Generally, the penaeid prawns of commerce are found closely associated with brackishwater environments.

All the species of prawns are not using the brackishwater environments as their nursery grounds. George (1973) remarked that considerable variations occur among the prawns both in the degree to which the brackishwater environment is put to use by each species in its life history and, in the distribution of the parents and juveniles population in the marine-brackish environments.

The estuarine, backwater and mangrove environments play a vital role in the life cycle of prawns and in the establishment of its fishery. Macnae (1974) commenting on the correlation between certain penaeid species and mangrove forests stated "no mangroves; no prawns".

Penaeid prawns of commercial significance from Porto Novo waters are *Penaeus indicus*, *P. mondon*, *P. semisulcatus*, *P. merguiensis*, *Metapenaeus dobsoni*, *M. monoceros*, *M. brevicornis* and *M. affinis*.

Information on their larval, juvenile and subadult abundance in space and time and their recruitment into estuaries, backwaters and mangroves is essential for a proper and optimum utilisation and sound management of the fishery. From the east coast information on penaeid prawns has been furnished by Jhingran and Natarajan (1966), Subrahmanyam and Rao (1968), Subrahmanyam and Ganapati (1971) and Rajyalakshmi (1972) among others. But the necessity still exists for detailed assessments from different coastal areas, estuaries, backwaters and mangroves.

Material and Method:

Present observations were conducted from January to December, 1977. Selection of stations was based on the availability of algal flora. Algae were fairly abundant during certain seasons and they provide adequate food, prote-

ction and shelter to all stages of prawns. Regular weekly collections were carried out in three different biotopes, namely estuary, backwater and mangrove regions of Porto Novo. Velon screen drag nets (mesh size 1.17mm) of length 3 meters and width 1 metre were used for the present investigation. This screen filtered the water as it gathered prawns during dragging. The prawns were thus taken for study.

Results:

Hydrography:

The hydrographical parameters such as salinity, temperature, pH and dissolved oxygen were estimated by standard techniques and methods during the course of our collections. The values are summarised in Table 1.

No remarkable salinity variations were observed between the biotopes. The lowest salinity values occurred during the rainy month of November, 1977 which coincided with the influx of heavy flood water from rivers and rivulets and reservoirs (Vellar, Killai, Komugi, Manimutha and Veeranam) draining into the area. This year (1977) it was accompained by a cyclonic storm and a number of deep depressions in the Bay of Bengal bringing in superfluous rainfall and unprecedented flood.

Species composition:

Seven species of penaeid prawns were found to be of commercial importance. They are listed below, together with their percentage composition in the total juvenile prawn population.

TABLE-I

Range of hydrographical values * (based on weekly samples) of Porto Novo inland waters (January to December, 1977)

Environmental Parameters	Range of values		
	Estuary	Backwater	Mangrove
Salinity ‰	0 — 34.3	0 — 34.0	0 — 34.1
Temperature, °C	26 — 34	25 — 36	28 — 35
Dissolved Oxygen, ml O_2/l	3.12 — 5.90	3.29 — 6.66	3.20 — 8.11
pH	7.5 — 8.2	7.2 — 8.1	7.2 — 8.1

* (Depends on tide at the time of collection. The area enjoys semidiurnal tides and the tidal influence is felt upto 10 km in the Vellar mouth, the backwater and the mangrove regions.)

Fig. 1. Chart showing the distribution and availability of the juveniles of Penaeid prawn species. The arrows indicates the routes of dispersal and distribution of juveniles of *Penaeus indicus*, within the estuary, backwater. channels and the mangrove forests and their water ways.

TABLE-II

Percentage Composition of Juveniles of Penaeid Prawns Among Porto Novo Biotopes

Species	Size range mm	Aquatic biotopes		
		Estuary	Backwater	Mangrove
Penaeus indicus	20-120	21.9%	33.6%	44.9%
Penaeus semisulcatus	15-115	46.9%	25.4%	2.0%

Metapenaeus dobsoni	10- 50	12.7%	6.8%	32.5%
Penaeus monodon	25-115	6.3%	10.3%	6.2%
Metapenaeus monoceros	12- 80	5.7%	11.4%	9.3%
Metapenaeus brevicornis	10- 46	3.3%	3.9%	3.8%
Penaeus merguiensis	20- 96	3.2%	8.6%	1.3%

Distribution and relative abundance:

Fig. I depicts the distribution, and table II shows the species and percentage composition of juveniles. Observations from our collections from these inland waters showed that most of the prawn species were available throughout the year. They showed dominance and availability in certain months and relative scarcity in some seasons. However, the year 1977 was unusual as the heavy unprecedented floods and superfluous rainfall had occurred. It affected the prawn fauna also. *Penaeus indicus* was available in all the biotopes and was dominant for most part of the year (10 months) closely followed by *Penaeus semisulcatus*. The maximum number of specimens of a species caught is mentioned as primary peak. The secondary peak denotes the next number of availability The numerical values of peaks varied between species.

a) Penaeus indicus:

It was very common in all the biotopes. It showed the primary peak of abundance from January to May and a secondary peak in September to November in the estuary, backwater and mangrove. More number of juveniles were collected from the backwater than from the other biotopes. Large number of post larvae of sizes 8-15 mm were collected from the shallow pools near the mouth of the river. *P. indicus* showed the maximum percentage (Table II) composition in the mangrove region. The maximum size (total length) of this prawn caught from the estuary was 142 mm.

b) P. semisulcatus.

This species was very common in the estuarine and backwater regions and was scarce in the mangrove region. They were usually found abundantly in the marine grass beds of *Cymadocea isoctifolia*, than in any other area. They occurred from May to October in estuarine and backwater environments. The peak was during August and September. The maximum size observed was 102 mm.

c) P. monodon:

This prawn, although common, was comparatively less abundant than *P. semisulcatus*. Primary peak was from January to March in all the biotopes. The secondary peak was noted in September in the estuary, August, September in backwater and November, December in mangrove region. *P. monodon* was absent in May, June and July months in the mangroves. The maximum length recorded was 147 mm.

d.) P. merguiensis:

This prawn showed a decreasing trend of abundance from January onward and recovered to reach its peak in May. It showed a decrease from June to December in the estuary. The size of the population becomes smaller from August and tapers off. They were absent in November, December months, in the backwater. In mangrove region *P. merguiensis* was abundant in January and February, but was less in the remaining months. The species was absent in March, April and September to December. More number of this species were found to occur in the backwater, than in the other two biotopes. 138 mm was the maximum length observed during the study period.

e) M.dobsoni:

This species was available in good quantity from January to May, then they began to diminish in numbers and again they staged a recovery and attained the peak in December in the estuarine water. In backwater they formed a primary peak in July and secondary peak during December. Its highest number was observed in December in the mangrove region. The maximum size of this species was 68 mm.

f) M. monoceros:

This species was abundant from January to April and August to November in the estuary, backwater and mangrove biotopes. It was caught in good numbers from the backwaters. The major peak was observed during June to September and a minor peak in December. The primary peak was observed in September and October in both estuary and mangrove regions.

A minor peak was noticed during April in the estuary and during January-February in the mangroves. The maximum size observed was 81 mm.

g) M. brevicornis:

This species occurred abundantly from January to April and during September and October. It occurred, although not in abudance, from May to August and November in the estuary. In backwater, the primary peak was observed during January-February and secondary peak during August-September. In the mangrove region, two major peaks of abundance with a minor peak were observed during February, June and August respectively. The maximum size was 70 mm.

Discussion and conclusion:

The Porto Novo aquatic biotopes are very rich in prawn fauna. They provide a very good addition to marine fishery. Many poor people in this area depend on mangroves and backwater prawns.

From the southwest coast of India, Menon (1952, '53) George (1962), George *et al.* (1968) and Rao (1968) have reported on the spawning period of penaeid prawns in the inshore waters based on an assessment of postlarval abundance. The present study indicates the presence of large numbers of juveniles in the samples, emphasizing that the spawning area should be near Porto Novo.

P. indicus constitutes maximum percentage of composition in the mangrove (Table II & III) biotope. These juveniles (also Table III) would browse on microbially infested leaves. Fell *et al.* (1975) state that the degrading leaves are converted by microorganisms to a high protein material that is consumed by small invertebrates which, in turn, are consumed by commercially important fishes and crustaceans. The abundance of *P. semisulcatus* could be correlated with the presence and relative abundance of the flora of these regions. The marine grass *Cynodocea isoctifolia* abundant in the estuary was not much in evidence in backwater and was absent in mangrove region. Subrahmanyam (1968) observed that *P. semisulcatus* juveniles were plentiful from March to June and September to October in Pulicat lake. He also found in Pulicat lake that the post larvae of *P. monodon* were usually rich during January to April and August to November. We found a similar feature here also. The secondary peak extends from August to December in all biotopes.

Srivatsa (1953) reported the spawning period of *M. monoceros* to be from February to April in the Gulf of Kutch. Our study shows the abundance of *M. monoceros* juveniles from August to September in estuary, from July to September in backwater and during September-October and January-February in mangrove region.

The prawn, *P. merguiensis* was abundant in January and May in the estuary (Selvakumar *et. al.*, 1977 also reported similar finding). They were higher in census during May to April in backwater. This species was generally scarce in the mangroves, being present only during January and April.

The present investigation fully agrees with the observations of George *et. al* (1968) and Rao (1968) on *M. dobsoni* who reported that *M. dobsoni* would breed throughout the year, and its peaks of population were in April, June through August and November-December for both the east and west coasts.

Of the species listed now from Porto Novo, the prawn *M. brevicornis* was poor in census, although it occurred in all the biotopes. They prefer backwaters as their nursery ground. Rajyalakshmi (1972) observed from Hooghly-Maltah estuarine system that *M. brevicornis* persisted as a fishery throughout the year, although it was quantitatively less during monsoon months.

TABLE–III

Occurrence of dominant species of Penaeid prawn juveniles

Biotopes	Dominant species	Peak season
Estuary	*P. semisulcatus*	August - October
	P. indicus	January - May

Backwater	*P. indicus*	January - May
	P. semisulcatus	May - October
	M. monoceros	July - September
Mangroves	*P. indicus*	January - April
	M. dobsoni	June - December

To put prawn farming on a firm basis regular seed collection centres/industries are essential. The simple scoop nets, push nets, shooting nets, and drag-nets are being put to use to collect postlarval and juvenile popu lations.

Velon screen drag net of (mesh size 1.17 mm) length 3 metres and width 1 metre seems to be a quite efficient net to collect post-larvae and juvenile prawns. Two persons holding the net (in shallow waters) from two ends of the net can easily wade through one foot to waist-deep water all along the coast or towards the bank. This screen filters the water as it gathers prawn fry during dragging. The prawn fry can then be transferred into containers.

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PRAWN SEED RESOURCES OF ADYAR ESTUARY AT MADRAS

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Introduction:

In many brackishwater areas, there are abundant supplies of naturally occurring post larvae and juveniles of prawns that can be utilized for grow-out operations in brackishwater prawn ponds. These seeds are available, and there is no need to wait for hatchery technology to be developed. Such seed resources are especially important for the small prawn farmers who can utilise their own labour to collect the seeds (Cook, 1976). Therefore, knowledge on the

Fig. 1
Map of Adayar area to show location of sampling stations

availability of wild seed resources is important to plan the development of prawn farming.

Presently one of the five sub-units of All Indla Co-ordinated Research Project on Brackishwater Fish Farming is functioning at the Santhome Brackishwater Fish Farm at Madras, Tamil Nadu. As part of the programme of work on seed prospecting in brackishwaters nearby the project area, investigations were undertaken on the prawn seed resources of Adyar estuary.

The Adyar river finds its source from the Guduvancheri hills in Kancheepuram taluk of Chingleput District, Tamil Nadu and after flowing about 25 miles, it empties into the Bay of Bengal at Adyar, Madras. (Fig. 1). It will be in spate during north-east monsoon period (October to December). The tidal influence is felt up to a distance of about four miles from the mouth. The estuary will be cut off from the sea during summer months (May to August).

Preliminary observations made earlier (Evangeline, 1972) have indicated the heavy recruitment of prawn seeds into the Adyar estuary. The present account is based on the detailed investigations carried out during the years, 1976 and 1977.

Material and methods:

A stretch of 2 km length from the mouth of the Adyar estuary was selected for the survey. For seed collections standard Midnapore type shooting nets were used. These nets were suitable to operate where a reasonable tidal flow was assured and the bottom was smooth and shallow. Therefore, they were operated near the mouth of the estuary where the conditions were favourable. In addition to shooting nets, drag nets (hapa nets and fine meshed local drag nets "Kondavalai") were also employed. These nets were operated through-out the 2 km stretch, especially in shallow regions. Shooting nets were operated to a minimum of two hours during spring highwaters. Other nets were operated both during spring and neap tides as well in high and low waters.

During the year 1976, the estuary was cut off from the sea during June and in 1977 from June to August and during these periods shooting net collections could not be made.

Hydrological conditions of the estuary were recorded at two stations, near the river mouth, where the shooting nets were operated and at a point west of the Adyar bridge. (About 1. 4 km from the river mouth)

Results and discussion:

Species wise catch of prawn seeds (nos) /man/hr from the experimental shooting net operations conducted in Adyar estuary during 1976 and 1977 are presented in Table 1 and the drag net operations in Table II.

TABLE I

Species - wise shooting net catch (Nos)/man/hr in the Adyar estuary during 1976 and 1977

	1976				1977			
	Species				Species			
Months	*P. indicus*	*P. monodon*	Metapenaeids	Total	*P. indicus*	*P. monodon*	Metapenaeids	Total
Jan	905	26	32	963	286	65	14	365
Feb	1646	14	114	1774	2865	32	69	2966
Mar	1655	42	61	1758	896	...	1210	2106
Apr	1210	39	856	2105	305	52	406	763
May	39	2	45	86	308	48	215	571
Jun	-	-	-	-	–	-	-	-
Jul	101	19	32	152	-	-	-	-
Aug	968	-	68	1036	-	-	-	-
Sep	1869	36	148	2053	3865	39	102	4006
Oct	402	21	161	584	20	2	8	30
Nov	36	20	39	95	302	29	165	496
Dec	41	29	69	139	1322	79	856	2257

TABLE–II

Species wise dragnet catch (nos)/man/hr in the Adyar estuary during 1976 and 1977

	1976				1977			
	Species				Species			
Months	*P. indicus*	*P. monodon*	Metapenaeids	Total	*P. indicus*	*P. monodon*	Metapenaeids	Total
Jan	2722	–	470	3192	832	416	32	1280
Feb	3824	–	621	4245	7676	74	365	8115
Mar	6419	378	47	6844	3950	19	4860	8829
Apr	3482	46	7310	10838	2840	468	1550	4858
May	568	4	378	950	2670	472	576	3718
Jun	-	-	-	-	568	72	165	805
Jul	1109	81	161	1351	-	-	-	-
Aug	4656	23	244	4923	-	-	-	-
Sep	9665	280	1025	10970	8568	226	365	9159
Oct	1379	58	523	1960	40	12	36	88
Nov	71	173	122	366	680	72	565	1317
Dec	223	185	378	786	2450	280	3260	5990

The hydrological data collected at the two stations are given in Table III.

TABLE III

Ranges of variations in hydrological factors at the two stations.

	STATIONS	
	Near river mouth	West of Adyar Bridge
Surface water temp. (°C)	25. 3 - 31.7	26.2 - 32. 3
pH	7. 3 - 7.8	7.1 - 7. 8
Dissolved Oxygen (ppm)	5.72 - 8.07	3.89 - 7.24
Salinity (ppt)	16. 8 - 31.27	4.87 - 28.73

Prawn seed resources:

The perusal of the table will indicate that prawn seeds are available in the estuary through out the year except during the period when the estuary is not in communication with the sea.

Seed of *P. indicus* are available almost throughout the year. However, the peak season appears to be January April and August and September. Drag net operations have yielded 9665 and 8568 seeds /man/hr during September 1976 and 1977 respectively.

Post larvae and juveniles of *P. monodon* are also available throughout the year and the peak periods of availability vary from year to year. However, considerable numbers are available during January, Mach to May, September and December. Compared to *P. Indicus* the contribution of this species is extremely poor.

Metapenaeids are respresented by *M. monoceros* and *M. dobsoni*. Though they are also available throughout the year, the peak season appears to be March-April and September for *M. dobsoni* and November and December for *M. monoceros*.

General observations:

Suitability of the gears employed:

Shooting nets seem to be efficient in trapping the post larvae of prawns. They are suitable to operate at places where, the bottom are suitable to operate at places where, the bottom is shallow and smooth and the tidal current is sufficient for filtering. In Adyar estuary, they could be operated only near the mouth, where conditions are favourable. As mostly post larvae (6–10 mm) are trapped by the nets, segregating the desired one from other varieties become difficult and time consuming. Large quantities of debris and weeds are also trapped along with seeds which necessitates clearing the cod end frequently. Separation of seeds from debris also consumes time.

Locating suitable collection Centres for operating shooting nets has always been a problem in small estuaries such as Adyar, where the mouth of the estuary is open almost perpendicular to the sea and wave action prevent the operation of the net for a considerable distance from the mouth. Beyond this distance, tidal velocity may not be sufficient for filtering. At times, after the floods, the shallow margin along the banks of the estuary becomes very steep and fixing of the net in such places becomes difficult. However, the shooting net collections serve to indicate the actual time of recruitment of prawn seeds from the sea into the estuary.

Compared to shooting nets, drag nets can be operated throughout the stretch, especially in shallow margins. Drag net operations at shallow margins and stag nant pools during the peak periods of recruitment of *P. indicus* yield large quantities of post larvae and juveniles (12 to 40 mm). The collection often yields 90-95% of pure seeds of *P. indicus*. As advanced post larvae and juveniles are filtered by these nets, segregating the desired variety becomes easy.

Distribution of prawn seeds in the estuary:

Post larvae and juveniles of *P. indicus* appear to congregate in the lower reaches of the estuary (upto 1 km from the mouth) where salinity normally exceeds 16.8‰ except during rainy periods. In the upper reaches where salinity is comparitively lower, they are scarce. They seem to prefer shallow margins with soft sand and debris.

Compared to *P. indicus*, post larvae and juveniles of *P. monodon* congregate in places of wide variations in salinity (4.87‰ to 28.73‰) However, their distribution seems to depend upon the nature of the margin of the shallow regions of the estuary. They are found to congregate in shallow margins and pools which are having plenty of marginal weeds.

Juveniles and post larvae seem to cling to the weeds and grow. A simple washing of the weeds is sufficient to trap the seeds.

Estimation of seed potential:

Based on the studies made during 1976 and 1977, it has been estimated that the estuary can meet the annual requirements of seeds of *P. indicus* for a cultivable area of 350 ha (for two crops). Seeds of *P. monodon* has been estimated to be sufficient to meet the annual requirements for barely 20 ha.

It has also been estimated that during the peak periods of recruitment, 5000 to 6000 stock size (25 to 40 mm) seeds of *P. indicus* man/hr could be collected during September and 2500 to 3500 seeds during March and August.

Effect of closure of the bar:

In most of the small estuaries in Tamil Nadu, the river mouth of Adyar gets cut off from the sea during summer months (May to August). The opening and closing of the mouth depends upon various factors such as the amount of flow of flood during north-east monsoon months, rainfall during south-

west monsoon period and the time of setting of the monsoon. An earlier rain in summer months will open the mouth earlier and vice versa.

Subrahmaniam (1972) has reported that the post larvae of *P. indicus* show abundance during two periods–January to April and June to September at Pulicat. Similar observations (unpublished) have been made by one of the authors (Sundararajan) at Killai backwater, Vellar and Coleroon estuaries in South Arcot District, Tamil Nadu

These waters normally do not cut off from the sea during summer month. Compared to these waters, the recruitment of the prawn seeds into the Adyar estuary is directly depending upon the behaviour of the bat during the peak breeding season. Even if the post larvae are available at the doors of river mouth they may not be able to enter the estuary if the mouth is closed. Because of the appearance of the bar, the first ingress of the seeds of *P. indicus* during June-July is missed every year. Similarly, the density of recruitment is also affected, if the mouth becomes shallow, within seven days after the estuary gets cut off from the sea, the pollution from City sewage mains which are let into the Adyar estuary, kills the entire fauna, including the prawn seeds.

From the foregoing account, it is evident that the Adyar estuary harbour seeds of commercially important varieties of prawn such as *P. indicus* in considerable quantities and available for exploitation for grow-out operations. Seed resources of *P. monodon* is limited.

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NOTES ON *MACROBRACHIUM ROSENBERGII* (DEMAN)- THE GIANT FRESHWATER PRAWN - ITS LARVAL REARING AND CULTURE WITH INDIAN AND EXOTIC CARPS.

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1. Introduction.

The giant fresh water prawn *Macrobrachium rosenbergii* (Deman) supports a fishery in the rivers and backwaters of Central Kerala. It is generally caught from the Vembanad lake and the rivers opening into the lake viz., Muvattupuzha, Meenachil; Pamba and Manimala. *Macrobrachium rosenbergii* being able to live and grow in varied types of fresh and brackishwaters and having an omnivorous food habit, has very promising possibilities for developing into a suitable species for culturing purposes.But the stocking of young prawns is greatly hindered by the dearth of prawn seed from the natural sources.

Several workers have attempted the rearing of *Macrobrachium rosenbergii* in India and other countries. (Ling 1967, Rao, 1967, Fujimura and Okamoto 1970, Meeran and Sebastian 1972). Commercial feasibilities of undertaking prawn farming using *Macrobrachium rosenbergii* are investigated at Fisheries Research Station, Edathua, Kerala and the present paper deals with this subject.

Macrobrachium rosenbergii- **rearing of larvae in captivity:-**

The result of rearing trials conducted previously prompted us to adopt outdoor culture for utilising the benefit of natural food, self purification of rearing medium and the larger moving space, the factors responsible for better growth.

Newly hatched larvae are found to be highly euryhaline and hence the time consuming slow acclimatization technique is not necessary before transferring the hatchlings to the rearing medium.

2. Material and Methods.

Live specimens of "berried" females were procured from adjacent paddy fields and rivers, with the help of local fishermen. These live specimens were kept one each in rectangular 'hapa' specially prepared with synthetic cloth and suspended in flowing river water. Chopped fish muscle was used for feeding. Daily observations were made on the development of eggs. Specimens with fully developed eggs were removed to glass tanks of 80 cm x 40 cm, filled to a depth of 25 cm with filtered clear fresh water and the water in the glass

tanks was kept well aerated.

Three outdoor cement tanks of 270 litres capacity each, were selected as rearing tanks and filled at a depth of 15 cms., with brackishwater, having salinity Roughly 2,000 hatchlings were trans- 12‰ ferred to each rearing tank directly from the hatching tank. *Artemia* nauplii were fed to the larvae twice on every day. The tanks were partly covered with tiles during day time to provide shade and completely covered at night using thermocole panels which prevent the temperature fluctuation of the rearing medium. The diurnal fluctuation of water temperature ranged from 27.5° C to 30° C during the rearing period There was no cleaning and flushing of water. However the water level was maintained by adding newly mixed fresh and sea water. There were also no aeration to the rearing tanks.

3. Observation.

The live specimens can be kept healthy and active by keeping them in rectangular 'hapa' suspended in flowing river water with less power. An accelerated development of eggs was also observed whenever there was a chance of getting rain water in the river. This phenomenon is seen to have been observed by Kewalramani, Sankolli and Shenoy (1971) in case of *Macrobrachium malcolmsonii*.

Eggs were hatched readily in fresh water and hatching completed within 1½ to 2 hours time. In all cases hatching was observed at early night hours. The growth was observed as very fast and encouraging in all the three tanks, when compared to that in indoor rearing tanks. Two small white glittering bands appeared on the ventral side of the abdomen on the 12th day and almost all larvae acquired this character within a week. At this stage the survival was recorded as 60%. After the 20th day there was a sudden decline in number due to predation by dragon fly nymphs. Mortality also occured to the advanced larvae by entangling themselves in the net work of filamentous algae grown on the bottom as well as on the side of the tanks. The first juvenile was settled on the 30th day. The metamorphosis of all the larvae was completed by the 40th day of rearing. The percentage of survival was worked out in between 3% to 12%.

Inspite of the high losses it is observed that hatchlings of *Macrobrachium rosenbergii* can be reared to juvenile stage successfully in outdoor tanks with less cost and less power. By applying corrective measures like preventing the entry of Dragon fly nymphs and the excess growth of filamentous algae particularly at the final stage of rearing; the survival rate can very well be increased.

4. Rearing of juveniles.

The juveniles were stocked in cement cisterns at the rate of 15 juveniles/sq. ms. after acclimatisation to fresh water. Shade and shelter were provided by putting floating water weeds and by keeping rubbles and bricks on the bottom of the rearing tank. The average size of juveniles at the time of stocking was 1.2 cm and average weight 0.029 gm (46 days old)

Chopped frog flesh and mussel meat supplemented with boiled rice were given at the rate of 5% of the body weight twice a day. To avoid pollution, the excess food items were siphoned out when needed. Of these items of food, juveniles showed preference to frog flesh. The intake of food material is visible through the transparent cephalothorax region. Young prawns are found to be very sensitive to the presence of food material. Feeding was very active during night hours.

Two horizontal bands were noticed on both sides of the carapace on the fourteenth day of observation when the juveniles were 60 days old. After one week one more band also appeared. The average size recorded after 2 months rearing was 4. 9 cm. with 80% survival, a size suitable for stocking.

Rearing of young *Macrobrachium rosenbergii* along with Indian and Exotic carps:

A 0.03 ha. pond was selected and manured with cowdung and inorganic fertilizers at the following rate in bimonthly intervals after clearing the excess weeds and unwanted fish.

Quantity per ha/year (kg)

Cowdung	5,000
Ammonium Sulphate	75
Single super phosphate	50

Fingerlings of the following species of carps along with *Macrobrachium rosenbergii* were stocked in the pond on 11.6.1976.

The details are furnished in Table-1.

TABLE - I

Details of stocking of Indian carps and *M. rosenbergii* in a 0.03 ha pond.

Species stocked	Nos.	Size at the time of stocking cm	Stocking rate per/ha.
Labeo rohita	50	8-10	1,665
Labeo fimbriatus	40	8-10	1,332
Cirrhinus mrigala	40	8-11	1,332
Catla Catla	5	8.5-12	166
Cyprinus carpio	50	6-8	1,665
Macrobrachium rosenbergii	25	5-6	832

Small patches of marginal aquatic vegetation were also maintained for providing shade and shelter for prawns especially during the moulting period. Artificial feeding was done by using coconut oil cake at the rate of 1 percent of the body weight.

For assessing the growth rate, especially that of *Macrobrachium rosenbergii*, trial netting were made by using cast net during August. Four specimens were recovered and after recording the length and weight the same were again released to the pond. An average growth of 10 cm. in length and 90 grams in weight,was recorded within a period of two months. subsequent trial nettings were not found successful due to high water level in the pond.

The harvest was made during April. The survival growth and production observed are tabulated in Table-11

TABLE - II

Survival, growth and production observed in the carp and prawn culture experiment.

	Rohu	L. fimbriatus	Mrigal	Catla	Cyprinus carpio	*M. rosenbergii*
No. Harvested	50	40	40	5	45	20
Percentage of survival	100	100	100	100	90	80
Total weight harvested (kg)	24	16	21	9	18	2.4
Average weight (in gms)	480	400	525	1,800	380	120
Average size (in cms)	32	31	30	31	26	22*

*Male specimens were absent.

production per ha/year

A; Fish : 2,900 kg
B. Prawn : 80 kg

The present study revealed that *Macrobrachium rosenbergii* can be cultured successfully along with Indian and exotic carps. Prawns can be harvested even early i.e., by October-November months when they attain the marketable size. The economics of this type of combined culture is attractive as the prawn is a valuable commodity in the freezing industry. It is interesting to note that in a well maintained pond, young prawns of about 5 to 6 cms., in length and 3 to 4 grams in weight are able to grow 15 cms weighing about 100 gms., in a very short period.

6. Conclusion.

Farming of juveniles of *Macrobrachium rosenbergii* to marketable size is relatively a simple procedure. But rearing of hatchlings to juveniles through the critical stages of early life is a difficult task where specialised feeding technique and keeping of highly conducive water environment are very essential.

Now the Kuttanadu Agriculturists are thinking for a change over to prawn farming from paddy cultivation as there is slump in the price of paddy. The need for maximising the production of prawn through culture is well known and is getting much importance now-a-days. The requirement of prawn seed is to be met fully by setting up hatcheries, then only the prawn farming become a viable proposition. A re-stocking project is also to be taken up with large scale stocking of juveniles of 30 to 60 days old, for replenishing the depleted *Macrobrachium* fishery in the fresh water zone of Vembanadu lake; which will enhance the prawn production as well as ultimately improve the socio-economic conditions of the people of that area.

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SEED REQUIREMENTS FOR INTENSIVE CULTURE OF PENAEID PRAWNS IN COASTAL WATERS, PARTICULARLY IN KERALA

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Abstract

The extent of estuaries and brackish waters in Kerala is estimated at about 0.243 million ha. Of this, 1,21,600 ha could be utilised for penaeid prawn culture. At present, prawn culture is being practised only in 5117 ha following the traditional practice of filtration. The prawns are harvested at regular intervals during the lunar phases, without allowing them to attain suitable sizes. *P. indicus* and *P. monodon* are the most suitable species for intensive culture, the former being the most abundant. The seed requirement of *P. indicus*, for stocking in the existing fields and the additional 5000 ha to be progressively brought under culture at a rate of 500 ha per year by the tenth year, will be 1317.5 million and on full development of 1,21,600 ha, it is estimated at 18,240 million. The potential estuarine and brackiswater resources of India is estimated at 1.7 million ha, of which 30,000 ha are currently used for traditional prawn culture practice mainly in Karnataka, Kerala and West Bengal. The seed requirement is estimated at about 5238 million for the existing fields as well as 500 ha to be converted into prawn fields immediately by each of the maritime states. If additional area of 500 ha is brought under culture by each of the states every year, the seed requirement, by the tenth-year will be 11,364 million. The urgent need for perfection of techniques of large scale seed production under controlled conditions to meet this enormous quantity of seed and of training research, technical and managerial personnel as well as operatives and fish farmers is stressed.

Introduction

Culture of prawns in impoundments adjoining the estuaries and backwaters of both Central Kerala and West Bengal is well-known since very early days. Prawn culture in brackish water fields is also being practised to some extent in Goa and Karnataka. The practice, though prevailing over the years, has neither undergone any change in its efficacy during its long history nor extended appreciably to other regions. However, with a wealth of information coming forth on the potential and prospects of prawn culture employing modern technologies, considerable interest is being evinced to bring in more and more areas into the fold of this aquaculture. The availability of prawn seed as and when repuired by

the farmers is, naturally, the most essential pre-requisite for the successful operation of prawn culture in extensive areas. In this context, an assessment of the seed requirements for the development of intensive culture of penaeid prawns in our coastal waters is attempted.

Extent of Coastal Waters in Kerala

The long stretch of coastal waters with bays, lagoons, estuaries and brackish waters comprise of the water resources available for prawn culture. However, the bays and lagoons, though they are highly productive and together constitute an important part of this resource, are not considered in the present study as the problems of prawn culture in these areas are more complex.

There are 44 rivers in the State, of which 41 flow towards west. A number of these rivers, such as the Pampa, the Periyar, the Bharathapuzha, the Valapattanam, the Korapuzha, the Dharmadam, the Pazhayangadi and the Payyannar open into the sea. The embouchures and the lower reaches within the tidal influx of these rivers, the brackish water lakes, the backwaters and the adjacent low-lying fields, and the mangrove swamps constitute the estuarine and brackish water resources of the State, the extent of which is estimated at about 0.243 million hactares. The brackish water lakes occupy an area of 1347 ha, the most important of which are the Vembanad, the Kayamkulam and the Ashtamudi. The other important brackish water lakes of the state are the Kavery, the Kottapuzha, the Valapattanam, the Korapuzha, the Valiangode, the Crangannore, the Paravoor, the Edvanadayara, the Anjengo, the Kadinamkulam and the Veli. The lakes such as Ashtamudi, Vembanad and Crangannore have permanent confluence with the sea into which others open only seasonally during the monsoon period.

All these estuarine and brackish water resources are not immediately suitable for penaeid prawn culture. It is estimated that about 1,21,600 ha, distributed in various regions as indicated in Table 1, could however be reclaimed and utilised (Anon., 1978).

TABLE - 1

Extent of brackishwater area which could be Reclaimed and used for brackishwater prawn culture.

Region	Area (ha)
Kuttanad	49,000
Shertallai	4,900
Cochin - Kanayannur	5,700
Parur	10,000
Trichur District	10,000

Vaikom		10,000
North Kerala		32,000
	Total	1,21,600

At present, about 5117 ha of low-lying fields adjacent to the estuaries and backwaters in the districts of Ernakulam (4000 ha), Trichur (597 ha) and Alleppey (353 ha), are being utilised for prawn culture. In most ot these fields, a variety of paddy resistant to slight saline conditions, is cultivated during the rainy season (June-September) and in the other season (October-April) prawns and other brackiswater fishes are raised.

Cultivable Species

Five species of penaeid prawns, namely, *Penaeus indicus*, *Metapenaeus dobsoni*, *M. monoceros*, *M. affinis* and *Parapenaeopsis stylifera* support the marine prawn fisheries of Kerala. Small quantities of *P. monodon* is also caught occasionally. All these penaeid prawns breed in the sea and have protracted breeding season extending almost throughout the year. The eggs and larval stages like nauplius, protozoea and early mysis develop in the sea. As they grow to late mysis and postlarval stages, the larvae, except those of *P. stylifera*, move towards shallow inshore waters and thence into the available estuaries and backwaters. These immigrating young ones form the seed for the present culture operations. The incoming tidal currents along with these young ones of prawns, fishes and various other organisms are let into the field through sluice gates. To maximise the entry of these, a kerosene lamp is generally hung during nights above the sluice gates. Escape of the thus trapped seed during the alternating ebb tides is prevented by barricading the sluice mouth with bamboo screens. This operation of trapping the seed in the fields is a continuous process throughout the culture season. It is interesting to note that the commencement of this culture operation in the seasonal fields in October/November, after the harvest of paddy, coincides with a peak period of abundance of postlarvae in the backwater region, thus facilitating an effective supply of seed. In the post larvel penaeid population in the Backwaters of Cochin, *M. dobsoni* constitutes 68.7%, *P. indicus* 17.9% and *M. monoceros* 13.4% (George, 1962.)

Intensive Culture

The traditional culture operation, though is a simple indigenous technique involving very little input, is nevertheless limited in its efficacy. The production is often low in quality as well as in quantity, obviousiy due to the indiscriminate stocking of both desirable and undesirable species brought in by the tide, and to the short period of impoundment during which no appreciable growth is possible. After a careful evaluation of this process, it is now suggested that intensive culture, which entails voluntary stocking of selective species of fast growing prawns and

regular monitoring, would enhance the quality and quantity of production.

Among the commercial penaeid prawns occurring in Kerala, *P. indicus* and *P, monodon* are found to be ideally suitable for intensive culture. These grow fast in impoundments, fetch high price and are in great demand. Of these two species, *P. indicus* occurs in the wild in greater abundance, and hence the following assessment of seed requirements for intensive prawn culture in Kerala relate to this species only.

Assessment of *P. indicus* Seed Requirement

Although, it is indicated that an area of 1,21,600 ha of brackish water is available for prawn culture In different regions of the state (Table-1), it may not be possible to utilise the entire area immediately for culture, as it requires detailed surveys, reclamation, construction of farms etc. It is envisaged that a minimum of about 500 ha of water area could be converted into prawn farms every year.

The prawn seed (*P. indicus*) requirement for stocking one hactare water area varies from 50,000 to 2 lakhs depending on the productivity of the field, quality of the water supply and method of culture operation followed. At an average stocking density of 1.5 lakhs seed per ha for 3 culture operations in an year, the progressive requirement of prawn seed is given in table II.

The requirement of prawn seed for stocking 5117 ha of the existing field and 5000 ha of additional field to be reclaimed by the end of the ten-year period at a rate of 500 ha per yeer, will be 1517.5 million. These seed can be obtained from two sources, namely, from the wild stock or from the hatcheries established for the purpose. The Central Merine Fisheries Research Inst-

TABLE - II

Seed requirement for intensive culture of *P. indicus* in the brackishwater of Kerala.

Area (ha)	*P. indicus* Seed requirement (million)
5000	750
10,000	1,500
20,000	3,000
30,000	4,500
40,000	6,000
50,000	7,500
60,000	9,000
1,21,600	18,240

itute has located several potential seed grounds of prawns in the surf region and in certain areas of estuaries and backwaters. From these grounds the seed can be collected by velon screen drag nets. However, it is well-known that the availability of seed in nature fluctuates widely from season to season and from year to year, and depends largely on the spawning success and the corollary survival of larvae and postlarvae. It is envisaged that about 70% of the above seed requirement could be met from those available in nature. To meet the balance requirement, it is essential to set up seed production centres.

Seed production in hatcheries includes the techniques of procurement of spawners of the selected species, their spawning and culture of eggs and larvae to stocking size under controlled conditions. While commercial hatcheries have been established in the countries like Japan, Taiwan, Philippines, Republic of Korea and United States of America, such hatcheries are yet to be established in our country.

Prawn Seed Requirement of India

The potential salt water resources of the country available for prawn culture comprise of numerous lagoons, bays, creeks, estuaries, and brackish waters in the coastal zone. The total extent of estuarine and brackish water resources is estimated at 1.7 million hactares, the state-wise distribution of which is given in table III. At present, a total of about 30,000 ha are utilised for a commercial brackish water prawns and fish culture in Gujarat, Karnataka, Kerala and West Bengal (Table III).

TABLE - III

State-wise distribution of estimated potential estuarine and brackishwater areas available for prawn culture.

State/ Union Territories	Potential area (million ha)	Area currently under commercial brackishwater/fish prawn culture (ha)
Gujarat	0.376	88
Maharashtra	0.081	--
Goa	0.019	NA
Karnataka	0.008	4,800
Kerala	0.243	5,117
Tamil Nadu	0.080	--
Pondicherry	**	--
Andhra Pradesh	0.200	--
Orissa	0.299	--
West Bengal	0.405	20,000
Total :	1.711	30,005

**840ha; NA - Not available.

The penaeid prawn fishery of the country is supported by about 15 species belonging to the genera, *Penaeus*, *Metapenaeus*, *Parapenaeopsis* and *Solenocera*. Although all these prawns are suitable or potentially suitable for culture, only 8 species, namely, *P. indicus*, *P. monodon* *P. merguiensis*, *P. semisulcatus*, *M. dobsoni*, *M. monoceros*, *M. affinis* and *M. brevicornis* are important at present on the basis of the available information on the biology, distribution, and availability of seed of these species. Table IV furnishes the distribution and abundance of seed of different species of prawns in various maritime states (Rao, 1972; Rajyalakshmi, 1973; Jhingran, 1977.)

TABLE - IV

Distribution and abundance of prawn seed in different regions.

Region	Species	Season for abundance
Gujarat	*P. indicus*, *P. merguiensis*	February – April
	M. kutchensis	February – September
	M. brevicornis	March – April
Maharashtra	*P. merguiensis*, *M. monoceros*, *M. affinis*	October – December
Goa	*P. monodon*	July – August
	P. indicus	February – May
	P. merguiensis	February – May
	M. dobsoni	February – April – May
	M. monoceros	September – December
Karnataka	*P. merguiensis*	December – March
	P. indicus	December – January
	P. monodon, *M. dobsoni*, *M. monoceros*	October – April
Kerala	*P. indicus*	October – May
	M. dobsoni	October – January – August
	M. monoceros	October – December
	M. affinis	October – December

SEED REQUIREMENTS FOR INTENSIVE CULTURE

Tamil Nadu	*P. monodon*	March – May, September – December
	P. semisulcatus	January – April, June – October
	P. indicus	February – May, August – September
	M. monoceros	March – September
Andhra Pradesh	*P. monodon*	September – April
	P. indicus	October – December
Orissa	*P. monodon*	April – May, November–February
	P. indicus	April – July, November–January
West Bengal	*P. monodon*	April – May, August–September
	M. brevicornis	July, October–December
	P. indicus	February – April

It is only recently that different maritime states have evinced interest in prawn culture and hence the level of development varies from State to State. The basic information on the ecological diversity, productivity of waters, differential distribution and quantitive estimations concerning seed is also scanty. In the absence of these data, estimation of prawn seed required for immediate development may not be pragmatic. However, to provide some indication of the seed requirements to base the developmental programmes, an attempt is made here on the basis of empirical knowledge. It is assumed that the water areas available in different maritime states are moderately productive, and that they may sustain a stocking density of 50,000/ha, under a crash programme, each of the states could convert a minimum of 500 ha of water area for prawn culture every year. At a stocking rate of 1.5 lakh seed for 3 culture operations per ha per year, the seed requirement to stock 500 ha by the States Gujarat, Maharashtra, Goa, Tamil Nadu, Pondicherry, Andhra Pradesh and Orissa where there are very little commercial prawn culture activities at present, will be 525 million. For intensive culture of prawns in the existing areas in Karnataka (4800 ha), Kerala (5117 ha) and West Bengal (20,000 ha) and for the additional 500 ha to be brought in under intensive culture immediately, the quantity of seed required is 4713 million. Thus, the total immediate prawn seed requirements of all the maritime States is estimated at about 5238 million and by the tenth year, 11363.5 million (Table. V).

TABLE - V

Immediate seed requirement for jntensive culture and the projected figure for tenth year.

State	Area (ha)	Immediate seed requirement (million)	Area to be developed by the tenth Year (ha)	Seed requirement (million)
Gujarat	500	75.0	5000	750.0
Maharashtra	500	75.0	5000	750.0
Goa	500	75.0	5000	750.0
Karnataka	5300	795.0	9800	1470.0
Kerala	5617	842.5	10117	1517.5
Tamil Nadu	500	75.0	5000	750.0
Pondicherry	500	75.0	840	126.0
Andhra Pradesh	500	75.0	5000	750.0
Orissa	500	75.0	5000	750.0
West Bengal	20,500	3075.0	25000	3750.0
Total	34,917	5237.5	75757	11363.5

General Remarks

During the last five years, considerable advancement has been made in the technology of prawn culture in the country. The Central Marine Fisheries Research Institute made remarkable progress in the field of seed production. Seven species of culturable penaeid prawns, namely, *P. indicus*, *P. monodon*, *P. semisulcatus*, *M. dobsoni*, *M. monoceros*, *M. affinis* and *P. stylifera*, spawned under controlled conditions and their larvae were reared to stocking size under different conditions. Considerable progress was also made in tackling the problem of larval feed. Similar studies have been reported on *P. merguiensis* (Raje and Ranade,1972) and on *M. brevicornis*. Encouraging results have been obtained on mass production of seeds of *P. indicus* and *M. dobsoni* with fairly good survival rate which would lead to the development of hatcheries (Silas and Muthu, 1977) However, considering the need for such an enormous quantity of seed that the nature may not be able to provide, immediate perfection of techniques of large-scale production of seed of selected species has become an urgent necessity.

In intensive prawn culture, selection of species plays an important role. The criteria such as the availability, growth rate, resistence to diseases, cost of culture and the ease with which the

species could be raised on a large scale determine the suitability of the species. It is already mentioned that among the species that occur in our waters and suitable for culture, *P. indicus* and *P. monodon* are the most important. These species have all-India distribution; they grow to large size in enclosed waters, and are in great demand. However, from the point of view of the capacity to produce relatively large number of eggs, faster rate of growth and hardiness, *P. monodon* is more preferred. But they are less abundant in the fishery than *P. indicus*. In the context of hatchery production of seed, procurement of their spawners poses a real problem. Endeavours are made at the Central Marine Fisheries Research Institute to induce maturation of ovary and spawning of these species as well as to domesticate them under controlled conditions .Mention may be made here of the successful domestication of one of the penaeid prawns, *Metapenaeus dobsoni* in the field laboratory at Narakkal (Silas and Muthu, 1978).

As prawn culture is in an early stage of development in most of the states training of personnel at various levels to properly develop the field is imperative. The Central Marine Fisheries Research Institute is already imparting training to prawn farmers under the Krishi Vigyan Kendra, Narakkal, in various aspects of prawn and fish culture, and also in the collection, identification, and transportation of seed. Under the regular programmes of the institute, short-term advance training is also being offered to research, technical and managerial personnel. As a large number of skilled operatives are required for the procurement of seed, it is necessary to forthwith strengthen these training programmes.

The prawn seed available in nature is composed of multiple species that coexist in the same ground. This being so, there is likely to be considerable wastage of seed, particularly of the less important species, should a large scale collection of prawn seed from the wild be undertaken by untrained personnel. This would not only result in an imbalance of the natural population, but also would affect adversely our capture fisheries. In order to avoid this situation, proper educational facilities must be extended to the fish farmers and seed suppliers on the conservation of this valuable resources.

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PROCUREMENT OF PRAWN FRY BY MPEDA

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MPEDA's experience during 1977–78, in procurement, storage and transportation of prawn fry is detailed below:

Prawn fry Resources in Cochin Backwater

Cochin backwater is a major nursery ground for the different spcies of prawn. The predominant species is Poovalan (*Metapenaeus dobsoni*), but being a slow growing species, which ultimately grows only to a medium size, the emphasis was on collecting Naran (*Penaeus indicus*) and Kara (*Penaeus monodon*). Kara fry is very seldom observed and the limited collections that could be made were from hideouts among weeds and crevices of rocks. Naran earlyfry, however, was available in fairly large quantities and shoals of them were observed, particularly in November/December perlod by the side of the proposed deep water wharf in the Candle island-Vallarpatt areas. Early fry appeared close to the surface at dawn. As the sun rose, they sank and disappeared. They could be easily collected using butterfly nets. Operetion of butterfly net of 50 cm. diameter could collect on certain days nearly two lakhs of early-fry in one hour. It is interesting to note that fry appearance is quite erratic and this could not be attributed to any known physical factors in the area. For collection of larger fry, Puduvypeen area was found to be very suitable. Here, the local Panchayat had auctioned the right for prawn filtration in a canal passing through this area, at a rental of Rs. 30,000/-for the season. Catches were best during the new moon nights when as much as 1 to 1½ tonnes of juvenile prawn were caught. The existing method of filtration resulted in complete mortality, as the successive collections piled up at the cod-end, crushing the earlier caught fry. MPEDA, therefore, introduced an improved version of a prawn filtration net, more or less on the same lines as the spawn collection net of Midnapore fishermen, with a floating gumcha. This technique was found to be effective and suitable for getting uninjured advanced fry (almost juvenile stage)

Problems of Storage

Very often, it so happened that the pond was not ready when the fry was readily available. In such a situation, the collections were transported to a

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hapa pitched in a suitable pond. Initially there was heavy loss due to crab holing. The problems of crab attack was got over by providing a wire screen around the hapa, but the use of smoked eel flesh failed to catch crabs from the area.

The most serious problem was the high cannibalism in the confined environment. It became necessary to transport the catch as quickly as possible to the stocking ponds, as any delay in transportation resulted in heavy loss due to cannibalism. The tendency to cannibalism is particularly high in the very early stages, but has not been noticed in the juvenile stage.

Transportation

Over short distances prawn fry was carried without difficulty in milk can type containers using boats for tranpott They were also transported overland by Jeep.

Two consignments of Kara fry were airlifted to Cochin from Calcutta taking 18 hours for the journey, including 12 hours waiting at Madras. In the first transportation made on 31 st May 1978. only 4369 fry out of 10,000 fry despatched, reached Cochin alive. The remaining were eaten up, there being no remnants of the dead ones. The second consignment, of 8,750 fry in 6 tins were sent on 23rd June 1978, where the survival was 53.5%. As in the case of Naran, cannibalism was more evident in the small size fry and the survival percentage was higher with lesser concentration (vide table given below)

Survival of Kara fry in the consignment airlifted from Calcutta to Cochin on 23rd June 1978.

Tins despatched.	Size of fry,	No. of fry in each tin.	No. received at Cochin alive,	Survival Rate.
1.	12–15 mm	2,000	955	48%
2.	-do-	2,000	904	45%
3.	–do–	1,500	870	58%
4,	–do–	1,500	878	58%
5.	–do–	1,500	835	58%
6.	25–30 mm	250	240	96%
		8,750	4,682	53.5%

Air transportation cost was fairly high, which worked out to Rs. 160/-and Rs. 107/ respectively per thousand live fry. This procedure of air transportation, although costly, was still viable. The indications are that it would be more economical to transport bigger sized fry and that too by rail, although this trial was not carried out.

Application of mohua oil-cake

Application of mohua oil-cake is now a standard procedure in inland fish culture, as it serves the double purpose of clearing the pond of unwanted fish

and manuring the pond. In many cases of prawn farming, the cost of mohua oil-cake application represent the largest single cost factor, as the oil-cake has to come all the way from Madhya Pradesh. The price of mohua oil-cake in 1977 worked out to Rs. 980/-per tonne, the current year quotation being even higher. There is also a serious doubt regarding its advantage as a manuring measure in an ecosystem in which the water is allowed to flow in and flow out. Some trials are being made with regard to the suitability of 'Odalanga' a readily available poisonus fruit. Endrine is a much cheaper and efficient prawn poison, but being a strong poison, would require careful handling and watch to prevent accidental human and animal poisoning.

As pointed out in another paper by same authors, mohua oil-cake emulsion applied at a critical dose was able to kill weed-fishes without harming the prawn under cultivation. Here advantage is taken of the behaviour of prawn in its habitat in the deeper waters during day time and the weed fish in the surface waters. Advantage was also taken of the tidal effect in diluting the poison effect by letting in water once the weed fishes were killed.

Harvesting of Prawn

One serious problem encountered is in the final harvesting of prawn. The existing practice of cast netting is time consuming and ineffective, Almost 30% of the cost of prawn farming was on harvesting (watch and ward excluded). In the later harvesting operations, it was found that prawn could be attracted to a corner of the pond by keeping a few petromax lanterns. However, since light penetration from air to water is seriously limited due to the critical angle, it would have been more effective if submersible lights were used. Alternately electric lights could be hung up in that area.

Konchu Seed for Fresh Water Culture

A large number of interested parties approached MPEDA for guidance in prawn culture in fresh water fields. Culture of 'Konchu' *(Macrobrachium rosenbergii)* was the obvious choice. A survey conducted in this regard in the kuttanad area revealed that:

1. 'Konchu' young ones can be easily collected, while fields are drained before paddy cultivation. But the screens used are large and only juvenile sized Konchu alone are usually caught. These are available for purchase at 30-50 paise a piece.

2. The Konchu when ready for breeding instinctively move to areas like Vaikom, where relatively higher salinities are obtained. While breeding and even hatching can take place in near fresh water conditions, the survival of the hatchlings depends largely on getting a certain minimum salinity.

3. There seems to be a need for a Konchu hatchery at the Vaikom area to repopulate the Kuttanadu area with Konchu.

4. Trial rearing of 'Konchu' has revealed that Konchu juveniles grow well

in paddy fields and do no harm to paddy. Many farmers prefer exclusive Konchu culture in view of the attractive economics in comparison to paddy culture. Still others feel about rotation of crop-one of paddy and another of Konchu. They feel that the Konchu will live on hay stumps, filamentous algae and small crustacea thereby recycling the available minerals.

OBSERVATION ON MASS REARING OF PALAEMONID LARVAE

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Abstract

By virtue of its export potential and fast growth, *Macrobrachium resenbergii* has become a much sought after species for culture in fresh water habitats. Though it is widely distributed in most states in India, it is practically impossible to collect from natural sources uniform size juveniles in any appreciable number and this has seriously restricted culture of the species. Controlled breeding and mass rearing of larvae in hatcheries has to be organised as the first step for commercial farming of the species.

Penaeid hatcheries with facilities to lower water salinity to 15 to 18 ppt. could be used for *Macrobrachium* larval rearing also. Brackish water areas providing the above water condition could be considered for *Macrobrachium* hatcheries. Basic hatchery requirements such as artificial aeration and feed are very much like those for penaeid larvae. The larval cycle in *Macrobrachium* takes 35 to 50 days or even longer depending on the quality and doses of feed and water quality. While *Artemia* nauplii is still the major item of larval feed, experiments have shown that by artificial feeding with the processed fresh tissue successful larval cultures could be achieved.

A commercial hatchery, should have as an adjunct, a fresh water farm for production of spawners (berried females) throughout the year. The size of this farm will depend on the target of production of juveniles, the fecundity of the species, level of brood stock management and expertise in hatchery operations. If the farm is properly managed by regular manuring and periodic artificial feeding, 10 to 15% of the stock would be in berry throughout the year. Depending on size the number of larvae produced will range from 5000 to 1,00,000 per spawner. This and the number of spawners available at a time will determine the magnitude of hatchery operations.

With green water, soyabean curd and minced and sieved flesh of Tuna as feed survival of larvae could go up to 30 to 50% at juvenile stage. Juveniles are gradually brought down to fresh water conditions and then released in ponds for growth.

NOTES ON POSTLARVAL REARING OF PENAEID SHRIMPS

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ABSTRACT

Penaeid postlarvae generally collected from natural sources are in the V th-VII th stage and these are reared in conventionally prepared nursery ponds or cement tanks with fairly high rate of survival. Keeping early postlarvae in hatcheries for a period of 2 – 3 weeks being a highly specialised operation, the nursery phase after V th postlarval stage is recommended.

In order to find out if penaeid postlarvae could be reared to advanced postlarval stages in intensive system, without artificial aeration, but with partial daily renewal of water and regular artificial feeding, three series of experiments were carried out in 23 plastic pools, each of 2 ton capacity, using Vth stage postlarvae of *P. merguiensis* and *P. monodon* and early fry of *Chanos Chanos* at the following densities of stocking:

Species	*Stocking Density No. Sq. m.*	*No/Ha*
P. merguiensis	1,000 to 4,000	10 to 40 miliion
P. monodon	1,000 to 1,500	10 to 15 million
C. chanos	500 to 1,500	5 to 15 million

During the rearing period of 15 days, compounded artificial feed in the form of fine, dry powder was given three times a day, each time the weight of feed dispensed amounting to the weight of stock in the pool. The feed consisted of:

Acetes sp.	–	50%:	Cocoanut oil cake	-	20%
Rice bran	-	20%	Tapioca flour	-	10%

Depth of water in the pools was maintained at 60 cms. Depending on population density 20–30 cms. of water was renewed, daily, in each pool. In selected pools 50 mg. of Cobalt Chloride was applied along with the feed every day. Survival and growth at harvesting were as follows:

Species	*Stocking Density No. / Sq. m.*	*Survival %* Range	Average	*Average Wt. attained* (mg.)
P. merguiensis	1,000	95-98	- 96	– 34.4
	2,000 –	56-91	– 75	- 14.0

	3,000	-	52–98	- 78	–	8.6
	4,000	–	36–78	- 55	–	9.5
P. monodon	1,000	-	63–84	– 73	–	19.5
	1,500	-	–	– 59	–	20
C. chanos	500	–	–	– 88	–	66.5
	1,500	–	–	– 85	–	52.0

Pools in which Cobalt Chloride was added tended to show slightly higher average survival.

The experiments have demonstrated that under field conditions where artificial aeration may not be practicable, intensive rearing of penaeid postlarvae could be successfully carried out provided water is partially exchanged daily. Use of plastic pools for rearing solves the problem of predators and facilitates complete harvesting of stock. The particular feed used has generally given very satisfactory results, but extra precautions are necessary to avoid over feeding and consequent mass mortality.

CONSTRUCTION AND MAINTENANCE OF SHRIMP FARMS FOR COMMERCIAL PRODUCTION

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1. Introduction.

The traditional practices of brakish-water fish farming in *bhasa-bada* or *bheris* in West Bengal and *pokkali* fields in Kerala are well known. Though the culture practice has existed on commercial scale for a long time, no scientific technology has been adopted by farmers to make the farms, economic, safe and efficient from the point of view of productivity and water management. In view of the high price earned by Indian shrimps in foreign markets, shrimp farming is increasingly being taken up commercially by neo-farmers and antrepreneurs in the maritime States of India and the necessity of designing and constructing shrimp farms for efficient operation and high production is being felt. In the present article an attempt has been made to throw light on some salient features of designing a shrimp farm, which may serve as guidelines for farm construction.

2. Selection of farm site.

The shrimp farms should be constructed in the coastal areas or lower estuary where saline water (20 ppt) and a good tidal amplitude is available for high production and efficient water management. Before finally selecting the site for farm construction a *reconnaissance* survey should be made to get a preliminary idea about the suitability of the site. The important factores which need attention during final selection of the site are:

i] Erosion:–Coastal mud flats are often prone to erosion due to tidal impacts. Nature and extent of the erosion should be noted and past history should be collected. Lands or islands under severe threat of erosion should not be selected.

ii) Soil characteristics:- Soil having a high sand content (more than 70% to 80%) will not be good for fish farm construction despite its good bearing capacity. The embankments of such soil will be too susceptible to erosion by wind and rain. Moreover it will also have a low nutritive value. Similarly soil of newly-formed islands in the mouth of estuary is also not good because it is generally soft and unstable. It has a poor bearing capacity. If the soil is too soft then it cannot withstand the superimposed weight of the dyke and the dyke may subside to a great extent. However, elevated lands which are subject to infrequent submer-

gence by tidal water are generally stable but a high expenditure on excavation is involved if the land is too elevated. The following proportion is good for making the dyke waterproof:-

Clay - 8% to 15% by weight
Sand - 60% to 80% ,, ,,
Silt - 12% to 25% ,, ,,

iii) Bushes and trees:-High incidence of bushes and trees will be responsible for the presence of too many roots in the soil which may cause great difficulties in constructing the dykes. But on the contrary if the farm is in close vicinity of the sea then the presence of a forest belt around the farm will help to protect the farm from the thrust of the tidal water.

3. Design of the farm.

3.1 Design of pond.

Scientific designing of a shrimp farm requires a study of the topographical characteristics of the farm site and record of tidal fluctuations round the year. Average current velocity also should be noted. Jhingran *et al* (1970) have suggested that one tidal gauge should be fixed for each I ha of water area to determine the tidal rise all over the land. But the author has found that if detailed contour survey of the entire site has been made correctly then only one tidal gauge reading will be enough to provide correct data on tidal rise in every part of the island. Based on this method alone the designs of the 200-and 500- ha fish farms in Henry's and Mahisani islands respectively have been prepared by the author.

Estimation of the depth of the ponds is an important feature of shrimp farm desinging. Depth of the pond should be such that water is maintained in the ponds to an adequate depth even in the lean months when tidal rise is minimum. For shrimp farm it is advisable that the average depth of the farm ponds should be 1 m.

The feeder canals should have a greater depth than the ponds so that water can be easily drained out whenever required. The bottom of the canal should be at a higher level than the average low water level (L. L. W. L.) of the main river or sea, so that complete dewatering of the farm is possible.

3.2 Layout of ponds and canals:

The detailed contour map of the proposed site should be thoroughly studied. Different sites might have different topographical characteristics. As for example, it has been found in the case of deltaic islands of Sunderbans that the contour of the land generally resembles the shape of an inverted saucer, the fringe areas being at a lower level than the remaining part of the island. In such cases, the fringe areas should primarily be selected for the construction of the ponds. Areas at relatively higher level should be selected for construction of stores, godowns, watch-sheds and other infrastructures. This will minimise the cost of construction.

The alignment of the main dyke of the farm should be such that a marginal land of about 30 to 50 m in breadth is

left between the dyke and the main river or sea to save the dyke from the direct tidal thrust. This land will also act as the source of earth whenever the need for repair of the dykes will arise. A feeder canal connecting the river with the main masonry sluice will have to be constructed to supply water to individual ponds, which will be connected with the main feeder canal with secondary sluices,

The ponds should be oriented in such a manner that maximum benefit can be derived out of the existing canals and creeks. If the farm is very large a single feeder canal may not be enough and supplementary canals may have to be constructed.

3.3 Marginal dyke.

The marginal dyke should be so high that it can most safely prevent the tidal water from overtopping and creating any breach. The area of the individual pond should be so determined that the earth available from excavation is sufficient to make this dyke. However, area of an individual pond cannot be increased to an unlimited extent because it will increase the cost due to lead.

Minimum freeboard is provided to prevent overtopping of the embankment by the wave. It also acts as a safety factor against many contingencies such as settlement of the dyke more than anticpated. Normally 1 m of freeboard is provided for shrimp farms.

As per the recommendations of American Society of Civil Engineers (A water resources technical publications, 1973), the freeboard required for small dams to prevent the wave overtopping the dyke is furnished below:-

Fetch, Miles	Normal Freeboard (in meters)	Minimum Freeboard (in meters)
Less than 1	1.2 m	0.9 m
1	1.5 m	1.2 m
2.5.....	1.8 m	1.5 m

3.3.2. Side slope.

The design slopes of an enbankmnet may vary widely depending on the quality of the meterial available for construction, foundation conditions and the height of the structure. Previous foundation may require the addition of upstream blanket to reduce the amount of seepage. Weak foundation may require the addition of stabilizing fills at either or both toes of the dam. In at purely homogeneous type of dyke it is anticipated that seepage will emerge on the downstream slope regardless of its flatness and impermeability of the soil if the water constantly stands on the dyke. In a shrimp farm, where it is assured that the river or sea water will not constantly stand by the side of the dyke to make its soil over saturated, it is still preferable to make the upstream and downstream slope flatter to prevent seepage as far as possible. A table furnished below shows the safe side slopes required to be provided for different type of soils:

Nature of Soil	Upto 8 ft. height	8 ft. to 15 ff height
Ordinary earth, soft clay, dry sand	1½ : 1	2 : 1
Loose earth, loose sandy loam	2 : 1	3 : 1
Wet sand	2½ : 1	4 : 1

Saline soil in brackishwater region becomes fluffy and pulverised during dry months of the year due to high evaporation and consequent release of salts and erosion by the wind. With the approach of monsoon further erosion will take place due to the battering action of intense rainfall. Therefore it is necessary that the side slope of the dyke should be protected from such action of wind and rain. Turfing with grass sods will protect the slopes of the dyke from this erosion and will stabilise the soil.

3. 3. 3. Crest:-

The quantity of available earth from excavation will mainly be the guiding factor for determining the crest width. In big ponds generally the earth available will be sufficient enough to provide broad crest. For commercial farms the crest should be broad enough so that light vehicles can ply over it. A width of 3 m or more, if more earth is available, is desirable. The crest may be made slanted slightly towards the river side so that rain water falling on the crest is prevented from flowing into the pond and rapidly silting the pond bed. Empirical formulae for determining the top width in feet: $W = \frac{H}{5} + 5$.

Where H is height in feet.

4. Construction of the dyke.

Before commencement of construction work, centre line of the dyke should be marked by pegs and complete profile should be set up at regular intervals and at every change of section.

Site should be cleared of roots, shrubs and grass, seat of the embankment should be prepared by removing loose soft top soil.

The dyke should be compacted thoroughly to increase its stability and power of resistance against settling, seepage and weathering action, burrowing by animals, etc. Earth in embankments should be deposited in layers not exceeding 25 to 30 cm stretching right across the whole section. All large clods should be broken. Each layer should be rammed well until all clods are flattened. Any roots of grass and/or shrubs should not be carried along with the deposited earth. Water should be sprinkled over the previous layer before the earth for the next layer is spread so that there is a good adhesion between the successive layers.

5. Maintenance of the farm.

Periodical maintenance of the farm is necessary to keep the farm dykes and ponds in good shape. Desiltation of the pond bed and redressing of the dykes should preferably be carried out

every year or once in two years just after the monsoon is over. In the case of long feeder canal, blind at one end, the silt deposition will be maximum at its blind end.

Silt may also be deposited from the dyke washing. Ponds should be drained off and the bottom exposed to sun for drying. On drying the silt will crack and form cakes which can be lifted conveniently.

Slip may sometimes occur due to the oversaturation of the soil and pose water pressure near base of the dyke and embankment. When a slip occurs all slipped portion and loose slushy stuff must be removed and replaced by fresh dry material, added layer by layer to give a proper slope.

Internal tunnels may be formed by burrowing animals like rats, crabs, etc. which may cause leakage. Leakage may also occur due to the presence of roots and trees which decay and result in pipings through the dykes. On detecting a leak, earth round the leak should be removed and fresh earth should be applied there with repeated ramming and compaction. Clayey earth is preferable for repairing these holes because of its high impermeability. Instead of minor leak sometimes major breach may occur. In such cases before the breach widens further due to the heavy velocity of water a semicircular bund should be constructed with bamboo matting and sand bag and water bailed out from within. Then earth is dumped on breached portion.

Some-times burrowing animals like crabs or eels make holes underneath the ground level, especially when the dyke is constructed on unstable foundation. joining pond side and canal side of the dyke to close such tunnelling, trenches may be made parallel to the toe-line of the embankment. Depth should be such that the tunnel falls within the trench. The cut-out trench should preferably be filled up with clayey soil and compacted by ramming. The impervious membrane will not permit the water from flowing out

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SITE SELECTION AND TYPES OF FARMS FOR COASTAL AQUACULTURE OF PRAWNS

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Introduction:-

It is estimated that India has about 2 million hectares of brackishwater areas, which could be devloped for culturing prawns and fishes. At present only about 30 000 hectares are utilised in Kerala, Karnataka and West Bengal for growing prawns and fish, employing traditional methods. The ever increasing demand for prawns has stimulated country-wide interest in scientific prawn culture and entrepreneurs are coming forward to establish prawn culture farms. However, prawn farms cannot be established indiscriminately in any brackishwater region. If the farm is to be economically viable, various factors have to be taken into consideration before selecting a suitable site. The criteria for the selection of a brackish-water farm site have been discussed by Schuster (1952), Hora and Pillay (1962), Schuurman (1966), Kow (1969), Caces-Borja and Rasalan (1969), Jhingran *et. al* (1970), Bardach *et. al* (1972), Milne (1972) and Sengupta (1976) in the light of the South-East Asian and Indian experience in the culture of brackishwater fish and prawns.

Site Selection

It is considered important to pay careful attention to the following points while choosing a site for construction of a prawn farm.

a. The topography and tidal regime of the area

b. Soil characteristics

c. Water characteristics

d. Availability of the natural seed resources in the neighbourhood.

e. The flora and fauna of the region

f. Freedom from pollution

g. Accessibility and nearness to markets

h. The legal regulations

i. The socio-economic condition of the locality

Topography and tidal regime:

The most important consideration is the elevation of the site in relation to the tidal amplitude at the site. The situation of the farm should be such that it should be possible to maintain a minimum water depth of 0.7 m in the ponds and to fill and empty the ponds utilizing the tidal rise and fall alone. To accomplish this, ideally, the tidal amplitude at the site should be around 1.5 m and the pond bottom should be a little above the mean low water neap tide level so that the pond could be

drained completely at any low tide and could be filled with water, if necessary, at every high tide. For proper pond management the ponds should be capable of being drained fully at least once a year and allowed to dry in the sun. To fix the level of the pond bottom in relation to the tide levels a proper contour survey of the area has to be made and year round data regarding seasonal variations in tidal heights at the site should be gathered. Data on speed of tidal currents and the pattern of water circulation in the area are also necessary for proper designing of the farm.

In the coastal areas of Maharashtra, Gujarat and West Bengal where the tidal amplitude is very high (3-5m), it is not advisable to locate the ponds near the coast as the embankment will have to be massive. But suitable areas could be located in the upper reaches of the tidal creeks where the elevation of the land will reduce the effective tidal amplitude.

Ideal location for a farm is a tidal mud flat which is uncovered during low tide and which is away from the main flow of the river or creek. It is essential that the farm is not affected by flood waters during the rainy season.

Soil Characteristics:

The nature of the soil at the site is of crucial importance. It has a direct bearing on the productivity of the ponds. In backishwater ponds benthic productivity is more important than the production of plankton. A clayey soil rich in organic matter encourages the growth of benthic blue algae which, along with the associated micro-organisms, Form the main food of most of the brackishwater animals. The micro-organisms responsible for nitrogen fixation and mineralisation of organic matter also thrive well on muddy bottom. The pH and carbon content of the soil are also important from the point of view of productivity and recycling of nutrients.

The structure of the soil is important from another point of view. Soil dug from the pond area itself has to be used for constructing the bunds and hence the soil has to have good water retention properties. Soil rich in clay is impermeable to water and can be used to form a firm, leak proof bund which is not easily eroded by wave or tidal action. Sandy soil is porous and is very poor material for constructing bunds.

Water Characteristics: Data regarding the seasonal fluctuations in water characteristics should be gathered at least for one year. The most important factor is salinity. Although the juvenlle penaeid prawns are euryhaline, the salinity range should normally be 10-35 ppt. Lower and higher salinities retard the growth of the prawns. Low salinity also makes them less resistant to parasitic diseases.

The optimum pH is around 8.0 pH lower than 7.0 or higher than 9.0 is detrimental to the health of the prawns. The methyl orange alkalinity should be 1 2 ml, to guard against large fluctuations in pH caused by the metabolic activity of the plants and animals in the pond. The dissolved oxygen content should not be lower than 3.5 ml/litre. Although

prawns can tolerate lesser oxygen concentration, their growth is affected. The turbidity of the water should not be high, as it would reduce light penetration and effect phytoplankton production. The primary productivity of the water should also be estimated by the C_{14} technique or the light and dark bottle oxygen method.

Seed resources: If the ponds have to be stocked with the prawn seed from natural sources, the abundance of the prawn seed resources in the neighbourhood should be assesssed by sampling for postlarval and juvenile prawns using various types of sampling devices. It is important that the prawn seed available should be those of the faster growing, large species such as *Penaeus indicus*, *P. monodon*, *P. merguiensis* and *P. semisulcatus* which fetch a high price.

Flora and fauna: The aquatic flora and fauna of the region should be studied The area should be free from rooted or floating angiosperms and a dense growth of filamentous green algae is also not encouraging.

Pollution: The site selected should not come under the influence of industrial effluents, city sewage out-falls or insecticide affected agricultural drainage. They would not only affect the growth of the cultured prawns but also render the farm products unacceptable to consumers.

Accessibility: The marketing facilities available for disposing the catch and the logistics of procuring the inputs necessary for constructing and operating the ponds should also be studied.

Legal regulations: Relevant information on the matter should be gathered from Revenue and Forest Department authorities. Any possible legal hurdles should be investigated.

Socio-economic conditions: Informationl regarding this aspect is important. For managing the farms efficiently, details regarding the seasonal availability of farm labour, local wages paid for skilled and unskilled labour, local traditions and customs etc. should be gathered.

Construction of Farm.

A viable farm unit could have a waterspread area of about 10 ha. A well laidout farm should have nursery ponds, stocking ponds and feeder canals. The lay-out of the ponds should be decided, taking into consideration the local topographical conditions. The design of the *Porong* type and *Taman* type ponds in Indonesia and the *Wun* type ponds in Taiwan for milkfish culture (Bardach *et. al.* 1972) may be consulted before planning the lay-out. The main difference between the Taiwan and Indonesian ponds is that in the former, each stocking pond has direct and seperate access to the feeder canal, while in the latter all the stocking ponds open into a common catching or "division" pond which has the main sluice gate. In the philippine designs for milkfish and prawn ponds all the nursery and stockng ponds open into a common catching pond which has direct con-

nections with the feeder canal.

Some general principles for the construction of a Farm are discussed here. The entire farm should be set apart from the estuary or creek by strong embankments which stand one meter above the highest flood level. It should be sufficiently broad to withstand the dynamic force of the tides and pressures created by the difference in water levels on both sides of the bund.

Normally the top of the bund should be as broad as it is high and the slope varies from 1:2 to 1:4 depending on the height of the bund and the material used for constructing it. The soil used should be free from roots and twigs which may decay later and cause leakages. The bund is constructed in stages by laying the excavatad mud slabs in layers which are compacted and allowed to dry in the sun before adding the next layer. Water should be sprinkled over the previous layer before the next layer is laid on, so that there is good adhesion between the layers.

If bunds have to be built in undrainable water-logged areas in Kerala, a hollow frame work in the shape of the proposed bund is erected on the site with bamboo poles, arecanut stems or split coconut trunks and lined with woven palm leaves or bamboo matting to hold the mud which is subsequently dumped into the framework. By the time the matting decays the mud would have settled and consolidated to form a good bund.

If the soil is sandy and porous it is mixed with bentonite which has the property of absorbing large volumes of water and swelling up to 8–20 times in volume thus plugging the pores in the soil. Chemical sealants such as sodium polyphosphates are mixed with poor soil to prevent leakage.

Alternatively, to prevent seepage, a clay core is provided in the centre of the bund. A clay core is a wall of clay anchored to the hard substratum below the pond bottom and is covered on either side with sloping, more porous soil. In the case of very porous soils, pond liners made of 2–4 mm thick membranes of polyethlene, polyvinyl chloride or buty rubber have been used on the inner surface of the bund.

The outer surface of the main embankment should be provided with granite rubble pitching followed by pointing to prevent erosion. In Japan, the inner surface of the embankments is lined with corrugated asbestos sheets which are pressed down by rectangular wooden posts laid over them at regular intervals. In Taiwan the inner surface of the bunds is lined with bricks laid on loosely. over the soil (Chen, 1976).

The top of the bund and the inner surfaces (if not specially protected) are covered with turf to prevent erosion. Slabs of turf are removed along with the soil from nearby areas and laid as a mosaic on the surface of the bund. The main embankment could be planted with coconut trees or mangroves.

The bunds in between the stocking ponds need not be as broad as the outer embankment but should be sufficiently broad to withstand the water pressure likely to be caused by differences in height of water in the ponds. Depending on the layout of the ponds some bunds may be sufficiently broad at the top to allow a vehicle carrying farm supplies to pass. The nursery ponds can be shallow, 30-40 cm deep and small in size (0.05 to 0.10 ha) and form about 5–10% of the total water area. The stocking ponds can be 1 to 2 ha. in area, rectangular in shape and 0.7–1.2m deep. Smaller ponds get heated up quickly in warm weather and experience wide fluctuations in pH and dissolved oxygen content. Large ponds provide a more stable environment for the prawns.

The nursery ponds can open directly into the stocking ponds through small sluices. Each stocking pond should get its water supply directly from the feeder canal through a sluice. The pond bottom should slope gently towards the sluice gate and could be traversed by shallow radiating or zigzag drainage ditches originating from the sluice gate. These ditches serve to drain the pond at the time of final fishing and also provide shelter to the prawns during hot days when the surface temperature shoots up.

The bottom of the feeder canals should be lower than the pond bottom so that the ponds can be drained completely, if necessary. The feeder canals should be sufficiently large to supply the water needed by the ponds and also to serve as a waterway for a raft or canoe to carry farm implements and feed to the ponds.

The main sluice on the outer embankment that communicates with the estuary or creek should be sufficiently large and sturdy, preferably made of concrete with manually operated iron shutters. For a small farm a sturdy, wooden open box sluice with two wooden-plank shutters sliding in grooves may be sufficient. The stocking ponds can each have a 1.0 - 1.3 m wide concrete or wooden open box sluice fitted with two sliding Velon screen shutters to prevent the escape of prawns and entry of unwanted fish and one wooden plank shutter to regulate the water level in the pond.

The land on the windward side of the ponds may be planted with casurina or mangrove trees to act as windbreaks. This will help in reducing erosion of the bunds caused by wind-induced waves.

Types of prawn farms in India.

The various types of prawn farms now functioning in India are briefly discussed here. In India prawns have been cultured traditionally in three types of farms viz. the *Pokkali* fields and "perennial fields" of Kerala (Gopinath, 1956; Menon, 1955; George, 1974) and the *bheries* of West Bengal (Hora & Nair, 1944; Pillai, 1954; Pakrasi, 1976). These systems have been very well discribed and a repetition is avoided here. However, the lines on which these systems could be improved are discussed.

Pokkali fields: There is a growing tendency among the *pokkali* field owners to abanden paddy cultivation altogether and completely switch over to prawn culture throughout the year. This move is in the worng direction for the following reasons: During the paddy growing season the fields are filled with water of very low salinity (1-2 ppt) which is not suitable for growing penaeid prawns. Further, the shallow *pokkali* fields become polluted with decaying organic matter and hydrogen sulphide formation towards the end of the prawn growing season in April-May when the temperatures are very high. While preparing the fields for the paddy crop this polluted water is flushed out and the fields are drained and allowed to lie fallow for sometime. The soil is also over turned. These operations are bound to have a salutary effect on the condition of the pond bottom. The repeated flushing of the upturned soil with rainwater also rids the soil of hydrogen sulphide and rejuvinates it. The paddy stalks which are allowed to decay in the fields after the paddy harvest also serve as good substrate for the growth of periphyton on which the prawns feed. The rotation of paddy and prawn crops in the same field serves the same purpose as the rotation of crops in agriculture. Therefore, it is advisable to continue with the traditional practice of growing paddy and prawns in succession. However, the following modifications may prove benefitial. At present the *pokkali* fields are fished frequently allowing very little time for the prawns to grow. It has been shown by George *et al*. (1968) that if the prawns are allowed to grow for a period of one month in the field they attain a larger size for which the farmer gets a higher price. Hence it is suggested that the fields should be filtered, starting from December, only once a month for a period of 3–4 days either during the full moon or the new moon phase, instead of the present custom of fishing frequently. However, stocking the ponds by opening the sluices at every high tide can be continued as at present. Further large meshed gill nets and crab lines could be operated in the deeper regions of the *Pokkali* fields every day to reduce the number of predatory fish and crabs that may now be taking a heavy toll of prawns.

In course of time when hatchery reared prawn seed of *penaeus indicus* and *p. monodon* become available in large numbers, the *pokkali* fields could be selectively stocked with these fast growing species and two crops could be raised, each of 3 months duration, during this season (November–May). At that time a velon screen could be kept permanently in the sluice gates to prevent entry of unwanted fish and prawns. The sluice gates will then serve the purpose of flushing the ponds with good brackishwater during every tides. Even then, it would be preferable to continue growing paddy during the monsoon season for the reasons discussed earlier.

There is great scope for extending the *pokkali* type of prawn cuiture to Karnataka and the Konkan where similar low lying paddy fields subject to tidal influence are present in the coastal tracts.

'Perennial fields' of Kerala

These fields are larger (upto 100 ha)

and deeper than the *pokkali* fields and are unsuitable for paddy cultivation because of their depth. Hence they are utilised for growing prawns throughout the year. Fishing is done at night during the low tide for 7-8 days around the new moon and full moon period with large sluice nets. prawns caught from these fields are larger and fetch a higher price (George, 1974). If large quantities of hatchery reared *P. indicus* and *P. monodon* become available these perennial fields will be ideal for growing them to marketable size.

The "perennial fields" of Kerala are very similar to the Singapore prawn farms described by Hall (1962) and Kow (1969). The mode of operation is almost identical. There is good scope for constructing the Singapore type prawn ponds in the estuarine regions of Mahanadi, Godavari and Krishna, where brackishwater creeks meander through mangrove swamps. The mangrove vegetation can be cut down and large 10-12 ha. enclosures built in suitable locations for trapping the young prawns that enter the ponds with each high tide, allowing them to grow in the ponds and fishing them with sluice nets when they try to return to the sea at low tide. In these areas the juveniles of the highly priced *P. monodon* are found in abudance and will form a good proportion of the pond catches.

Bheris of Sunderbans:

The *bhasa badha* fisheries in the *bheris* of the lower Gangetic delta differ from the prawn filtration in the *pokkali* fields of Kerala in the following respects: Prawns form the predominant component of the catch from the *pokkali* fields while fishes, mainly mullets and *Lates* form the main catch form the *bheris*. While the *pokkali* fields are fished almost continuously, the *bheris* which are stocked in February-March are harvested only in September-November. The *bheris* are also deeper and considerably larger in extent than the *pokkali* fields.

The time is now ripe for transforming the West Bengal *bheris* into full fledged prawn culture farms by partitioning the large areas into more manageable stocking ponds, 2–3 ha. in extent, and by constructing smaller nursery ponds for rearing the postlarvae of *P. monodon* to stocking size. Already there is an organised trade for the supply of *P. monodon* fry in W. Bengal and this could be made use of for stocking the ponds. By suitable pond management techniques the predatory fish could be kept out of the ponds and the prawns could be grown in monoculture or along with mullets.

Salt pan farms:

In the Manakuddy estuary at the extreme end of the Indian Peninsula an elegant system of culturing *P. indicus* in the salt pan reservoirs has been developed and it has been studied in detail by Suseelan (1975). The reservoirs are stocked selectively with juveniles of *P. indicus* caught from the nearby estuary and harvested after growing for three months. This system could be adopted in other salt pan areas where sea water from creeks is stored in large reservoirs before being fed to the evaporating pans. The salt pan

operators in the Godavari estuary are showing interest in culturing *P. monodon* in the salt pans during the rainy season and the Kakinada Centre of the CMFRI is assisting in this new endeavour.

Coconut grove farms:

The CMFRI at Cochin has initiated prawn culture in a unique ecosystem comprising the narrow brakishwater canals that are found in between the trees in the coconut groves of the Vypeen Island. At present these canals are not utilized for any purpose. By fixing a small sluice to the canal that communicates with the brakishwater canal system the water level inside the coconut grove could be controlled. The early juveniles of *P. indicus* (26-30 mm) collected from the back waters were stocked in these canals and harvested after 3 months when they had attained a size of 111-115 mm. The harvest in two such farms was so encouraging that the system is fast becoming popular in the Vypeen Island and many more coconut grove owners have taken up prawn culture in their fields.

In addition to the above mentioned ecosystems, the possibility of constructing large intertidal and sublittoral enclosures (Milne, 1972; Shigueno, 1975) and large floating cages (Milne, 1972) for growing prawns should be explored. Such facilities can be constructed only in calm, enclosed bays where the installations won't be damaged by strong wave action. In India such places are likely to be found in the Andaman Islands, Gulf of Kutch, the Kakinada Bay and the small bays on the Konkan coast.

Remarks

The existing facilities for culturing prawns in India have been built by the farmers themselves using very simple techniques. Many engineering problems crop up while designing and constructing a prawn farm on scientific lines. Farm engineering for marine and brakishwater aquaculture is a new field and our know-how is limited. There is an urgent need to develop new designs and innovative techniques for constructing bunds, sluices and canals to suit the local conditions and for utilizing new building materials for making the constructions economical and more durable. Therefore efforts are now being made to intensify research in this field and build up the necessary expertise to cope up with the rapid expansion of aquaculture activities that is bound to take place in the coming years.

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BRACKISHWATER FISH FARM - CONSTRUCTION AND MAINTENANCE

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Introduction

The Brackishwater Fish Farms can be formed in the mangrove areas, mud flats, low lying areas, swamps, tidal marshes as also in the inter tidal areas along the cost. Besides some paddy fields and salt pans which could advantageously be used as farms in some seasons. A thorough knowledge of the area and local experience coupled with scientific, technical and engineering expertise can help forming good farms. The information on geographical and climatic conditions, nature of soil, tidal amplitude in relation to elevation of site and duration of tidal influence, susceptibility to tidal waves, availability of stocking material in the vicinity, pollution effects, inrush of fresh or rain water from the catchment areas and approachability of the site are important for planning construction of the farms. Risk of poaching and labour problems etc. are also important considerations. Each problem is considered on its own merits and demerits. By experience very few sites are found to be ideal with all the desirable features.

With the keenness of the Government and increased awarenese of the Industry, we have to plan development of brackishwater fishery resources to bring maximum area under culture by taking a broad view in selecting the sites, overcoming some of the disadvantages, which could be overcome with the adoption of modern technology.

Selection of farm site:

The site should get sufficient tide water say a minimum of 0.7 meter height throughout the year or culture period and maximum of 2 meters or more upto which the protective embankment can easily hold. A reference to the Tide Tables published by Surveyor General of India for the past ten years will give a general idea of tidal amplitude of the area. The tidal influence to a particular site can also be deduced by practical observation for a short period. The site should be well protected naturally as far as possible from the tidal actions. A fringe of mangroves abutting the site is an advantage. The areas to be avoided or less preferred are rocky, sandy,

Present Address: Brackishwater Fish Farm,
Andhra Pradesh Fisheries Corporation Ltd.,
Kakinada.

too much elevated and areas prone to annual cyclonic tidal waves or submersion. The Farm should have protective (outer) embankment which should remain intact under natural conditions; clay soil, clay mixed with sand are preferable. Otherwise also the improvement of soil condition is a matter of effort.

The ideal elevation of the site, from the economic point of view, would be one in which the earth to be excavated for getting required depth of water would be sufficient to construct required dykes and at the same time the bottom level of impoundment should be such the water could be bailed out at low tide.

Layout:

It is generally influenced by the size of the Farm. It is always advantageous to form the ponds according to the site, instead of prescribing a pattern. The natural channels and impoundments existing in the site could be advantageously utilised while preparing a layout. As far as possible the Farm should have a supply channel with a mechanically operated head sluice. Independent inlet-cum-outlet (inlet in high tide and outlet in low tide) connecting the main supply channel is an added advantage. Proportion of nursery versus rearing (or stocking or culture) ponds depends upon the size of the stocking material available in the area. However, a maximum nursing area of one tenth of the Farm is advisable. Nurseries could be located at the tail end of the farm in case of copious supply of tidal water, otherwise nearer the main sluice.

Construction

The time chosen for construction of Farm will tell upon the cost of construction. The lean months, are best chosen for this purpose. The Tide Tables will give guidance for this purpose to add to the local experience. The timing of the engagement of labour force should be arranged keeping in view the increase in tidal amplitude towards the full moon and new moon days. The working hours of excavation is to be so arranged as to take maximum advantage of the low tide period, without loss of man hours waiting for the tide to recede.

The site should be cleared of mangroves and shrubs first and then the roots while excavating. The remains of roots may spoil the dyke by sprouting or decay which causes internal tunnelling. The size and shape of spade to be used will be dicided by an experienced worker to take advantage for removal of more earth for the same effort, depending upon the nature of soil. For loose and sandy soil broad spade and semi loose and clayey soil long narrow spade will work better.

Dykes and sluices:

It is difficult to prescribe the width of the dykes. It depends upon the earth to be untilised advantageously and nature of soil. It can be said that the outer dykes or protective embankments should be strong enough to protect the farm atleast from the normal cyclones of the area. The height should atleast be one metre higher than high tide. For a large farm the crest width of the peri-

pheral dyke should be 3-5 metres wide, this could also facilitate movement of vehicles for reaching the stocking material, manure, farm equipment etc. besides the construction material. The inner pond dykes should be 2-3 metres in width. They should have sufficient slope say 1:2 or more. It is advantageous to have stone paving or turfing on outer side to prevent erosion, on the outer dyke. The inside or secondary dykes should have more slope. Sufficient berm of not less than 2 metres will help preventing stoppage of soil from dyke into pond.

Sluice:

It is desirable not to change the course of tidal water flow. The pond sluice should be located in relation to the flow and preferably be a masonary structure with a mechanically operated sluice gate made of seasoned and treated wood. The structure should be big enough to feed the ponds to the required water level or drain out water from the ponds sufficiently in a short time say atleast one forth to one fifth of the area should be filled or emptied at a time. The size of inner sluices (inlet) should also be decided accordingly. The engineering calculations of rate of flow of tidal water is to be taken into account. (Tidal water velocity is calculated at 2 feet per second, approximately for Kakinada area.) During construction, the required grooves are to be provided for fitting in wooden shutters or mesh screens to regulate water. The size of inlet for each pond is to be decided according to the size of the pond. The use of palmyra trunks, if locally available, may help in construction of sluices including the main sluice gate, along with use of sand bags made from the used cement bags, fertiliser bags or plastic bags used for fish seed transport on a temporary basis. The bamboo screens also play an important role in the construction and management of Brackishwater Farms.

The depth of main supply channel should be more than that of the ponds. The slope of the bottom of the ponds sholud be towards the inlet (outlet). This facilitates the draining of water completely from the pond, which is very essential for harvesting particularly in case of shrimp which is found to be a real problem and also to dry up the ponds occasionally.

Utilisation of salt pans and paddy fields:

With the experience gained in the culture of fish and prawn particularly the latter at Sri Krishna Salt Pans, Vadacheepurupalli near Visakhapatanam and salt pans at Kakinada, I am very much convinced that the salt pans can advantageously be utilised for culture of prawn and fish. The dykes are already available, but may require strengthening . The sluices are to be remodelled to fix up synthetic fibre screens to prevent the escape of stocked material and entry of extraneous fish and other fauna which are predatory. With very little modification the salt pan reservoirs can be made best use of, for culture, for most part of the year (perhaps excluding only May and June, when the salinity increases). A maior part of the complete salt pan complex in the off

season say June to December could be used for culture of fish and shrimp, without detriment to the interest of salt culture. Similarly the paddy fields could be utilised for fish and prawn culture with minor modifications to retain the required level of water and by providing protective screens.

Maintenanc of the Farm:

The dykes of brackishwater ponds are more susceptible to damage due to loose soil conditions, force of tidal waters, rough weather, improper removel of tree trunks and roots, during construction, and burrowing activities of aquatic animals like crabs, eels, red mud worms, shell etc., which live in the bunds and make the soil loose. Periodical and timely maintenance of these dykes for control of this menace would be easier and less expensive, although properly planned and constructed dykes require less attention in the long run.

Desilting of pond bottom, feeder canals and particularly the inlet-cum-outlet sluices ones in two or three years may be necessary, depending upon the silt deposition brought by the water and dyke washing etc. The tail end of the feeder canals and ponds, gather more silt where detritus get collected due to wind action and water drive. The desilting of these parts should be attended to more often. The desilting operation is to be carried out by draining out the pond and drying and removing the silt to the dykes.

Any leaks, caused by natural scouring of water action, tunnelling and burrowing by aquatic animals, which sometimes include Otters, should be attended to immediately by filling them with clayey soil brought from outside, if necessary. Bamboo screens, sand bags (used polythene or gunny bags) would help in for arresting leakages and breaches.

The sluice gate structures are to be properly maintained by coal tar painting and other structure with grease and burnt oil. The aquatic mammal menace is effectively tackled by keeping constant vigil and scaring them away by torch lights or by crackers and by destroying their hide outs. Trained dogs will do very good job at the Farms.

Erosion in big brackishwater ponds due to wave action is a common observation. To minimise the erosion suitable turfing is recommended. Pitching the dykes on the water front with dry palmyra leaves, which prevents the water force on the soil of the dyke directly, is a common practice in brackishwater farm particularly in salt pans.

Good management is as important as having a well constructed brackishwater fish farm.

DESIGN AND CONSTRUCTION OF SLUICE FOR SHRIMP FARMS IN INDIA

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Introduction

Wooden box-type sluices closed on four sides and with rectangular openings, or bamboo sluices, locally known as *goi* are extensively used by fish farmers for taking in the tidal waters in embanked enclosures which are commonly called *bhasabadha* fisheries or *bheries* in deltaic West Bengal (Hora and Nair, 1944; Pillay, 1954; Hora and Pillay, 1962). Wooden sluice gates with bamboo gratings for controlling the tidal flow are similar type of sluice structures largely in use in brackishwater fish ponds in the backwater of Kerala (Pillay, 1948). Hickling (1971) has also reported the use of wood or bamboo gates for controlling the flow in fish ponds, called *pupukan* in northern Luzon in the Philippines.

However, the current practice of taking in tidal water through wooden sluices in brackishwater prawn and mullet farms is mainly based on age-old tradition and experience and has no scientific basis or engineering expertise in designing the shape, size and suitability of the sluice structure. Some work on the engineering aspects of sluices has been conducted while preparing the present communication which deals with the design and constructional aspects of sluices for shrimp farms in India.

Design consideration.

Regular supply of water to a prawn farm is achieved as a result of tidal inundation in the area. Based on the tidal range at a particular farm site, the cross-section of the sluice opening is so designed that the discharge is sufficient to fill the farm ponds with their required volume of water within the tidal cycle. The economical section of a sluice opening for the best discharge is a rectangular opening where the base width is twice the depth of the sluice.

But it is not suitable from practical view point as there are operational difficulties in lifting a big gate. Hence width of the gate should be necessarily so small that no operational difficulties are experienced during manipulation of the gate against the tidal rise.

Selection of materials.

Soil type of the farm site where the sluice is to be constructed is an important factor and determines the choice of materials for structural work of the sluice. Soils in the deltaic regions generally contain a higher percentage of silt, which has a low consistency and poor bearing capacity for supporting a heavy gravity load. In cases, however, where the shrimp farm is to be constructed very near the coastal belt and, in locations, where the tidal head is high, it becomes necessary to costruct costly permanent masonry or reinforced cement concrete sluice structures to regulate the flow of water. Such heavy structures are also capable of withstanding the tidal onslaughts. In such cases, proper investigation of the foundation soil needs to be made and, if required, necessary foundation treament is given before construction is started.

Best quality, seasoned, ***sal*** wood *(**Shorea robusta**)* is the most suitable material for construction of small sluice gates as the structures built with ***sal*** wood are durable and have a reasonable life expectancy in brackishwaters. Since the structures are not too heavy, no elaborate foundation arrangements are required for their installation.

Location and operational level of the sluice.

It is essential that the floor level of the sluice and also the pond bottom should be fixed in relation to the tidal range at the farm site. In order to maintain a brackishwater environment in the shrimp pond and also to ensure a satisfactory supply of water and its replenishment, it is necessary that the sill level of the sluice is kept above the low water ordinary neap tide (L.W.O.N.T.). If the pond water level is maintained below the high water ordinary neap tide (H.W.O.N.T.) then easy water movement, circulation and free exchange of water is accomplished during every tidal cycle (Milne, 1972), and the pond water may be completely drained out at the time of harvesting. The ideal brackishwater environment can be maintained in the pond if there is daily interchange of water in the pond.

Design and construction of a closed box-type sluice.

Closed box-type sluice is basically a rectangular wooden box whose four sides are covered by wooden planks and which is fitted within the earthen embankment.

Structural details.

As the sluice box remains within the embankment it has to support the vertical earthload of the embankment resting on the top of sluice box. Both side verticals of the sluice box have to resist the horizontal thrust exerted from the full width of the earthen embankment. The base or floor of the sluice box which is always in submerged

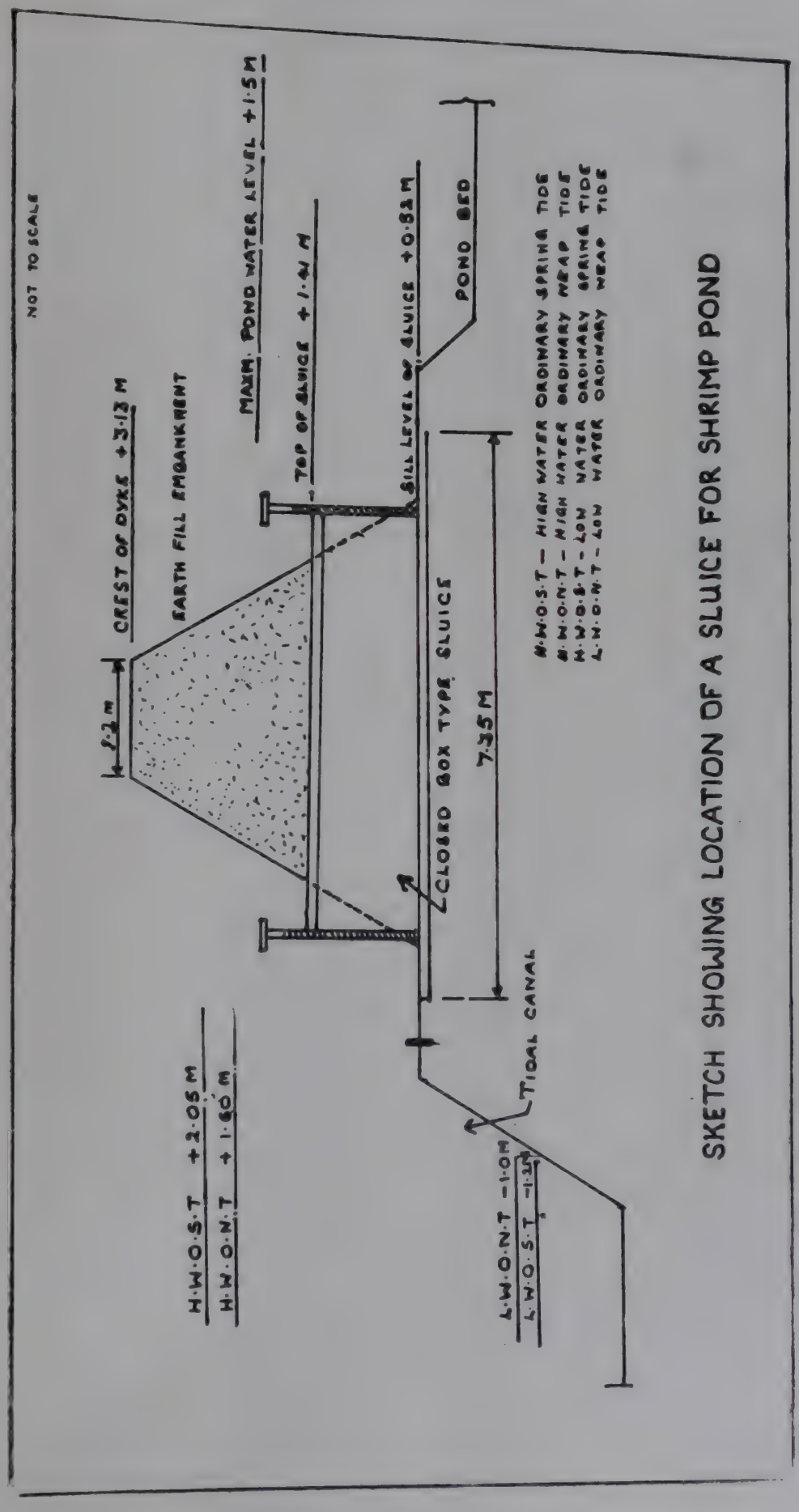
SKETCH SHOWING LOCATION OF A SLUICE FOR SHRIMP POND
NOT TO SCALE
CREST OF DYKE +3·13 M
EARTH FILL EMBANKMENT
MAXM. POND WATER LEVEL +1·5 M
TOP OF SLUICE +1·44 M
SILL LEVEL OF SLUICE +0·83 M
POND BED
CLOSED BOX TYPE SLUICE
7·35 M
TIDAL CANAL
H·W·O·S·T +2·05 M
H·W·O·N·T +1·60 M
L·W·O·N·T -1·0 M
L·W·O·S·T -1·3 M
H·W·O·S·T – HIGH WATER ORDINARY SPRING TIDE
H·W·O·N·T – HIGH WATER ORDINARY NEAP TIDE
L·W·O·S·T – LOW WATER ORDINARY SPRING TIDE
L·W·O·N·T – LOW WATER ORDINARY NEAP TIDE

Fig 1. Location of Sluice

condition is subjected to uplift due to sub-soil water pressure.

So, to have a sluice structurally stable against the above external forces, every component part of the sluice must be so selected that they are safe and sound.

Designed sections of various component parts of a closed box type wooden sluice which has been used for controlling the water flow to prawn pond at the Bakkhali Farm are as follows:–

Thickness of the top planks = 3.5 cm
,, side ,, = 2.5 cm
,, base ,, = 3.5 cm
Beams for frames = 10 cm x 6 cm

Frames are placed 75 cm apart. The sluice sustains a vertical earthload of 10,000 kg/m spreading over a height of 1.8 m above the sluice.

Construction.

The construction of sluice box is simple. The frames are first held in position at 90 cm apart and then base planks and top planks are firmly connected with the frames with the help of 10 mm dia. nuts and bolts. Once the alingment of the sluice is set, the lateral planks on both sides of the sluice box are similarly connected with the supporting frames by 10 mm dia nuts and bolts. The planks are provided with half-lapped joints while the beams should invariably be provided with dove-tailed joints to impart rigidity. The spaces that may be present between the adjoining planks are all caulked with cotton threads and a thick coat of coal-tar is given afterwards.

Simple wooden lift shutters or slide gates are provided at both ends to work as control devices for the sluice. These gates work in the vertical grooves which are left in the sides of two neighbouring posts forming the frame of the sluice and similar grooves are left in the base beams where the gates rest. For making the gates leak-proof, aluminium channels or rubber-lining may be provided in the grooves and on the sliding edges of the shutters. The gates may be operated by using man-power or with the help of radial wheel and gear rod lifting device.

Velocity and Discharge.

Discharge of tidal flow through the sluice into the shrimp pond is entirely dependent on the tidal motion in the rivers, estuaries, and tidal channels, created as a result of the tides in the sea. Velocity of current increases or decreases with the change of tidal range. Thus, any change in the water level or variation in the tidal currents in the supply channel directly affects the depth of inundation at the sluice head, and consequent discharge to the shrimp ponds through the sluice opening.

Below is presented a velocity discharge relation at a sluice head during high water ordinary spring tide (H.W.O.S.T.)

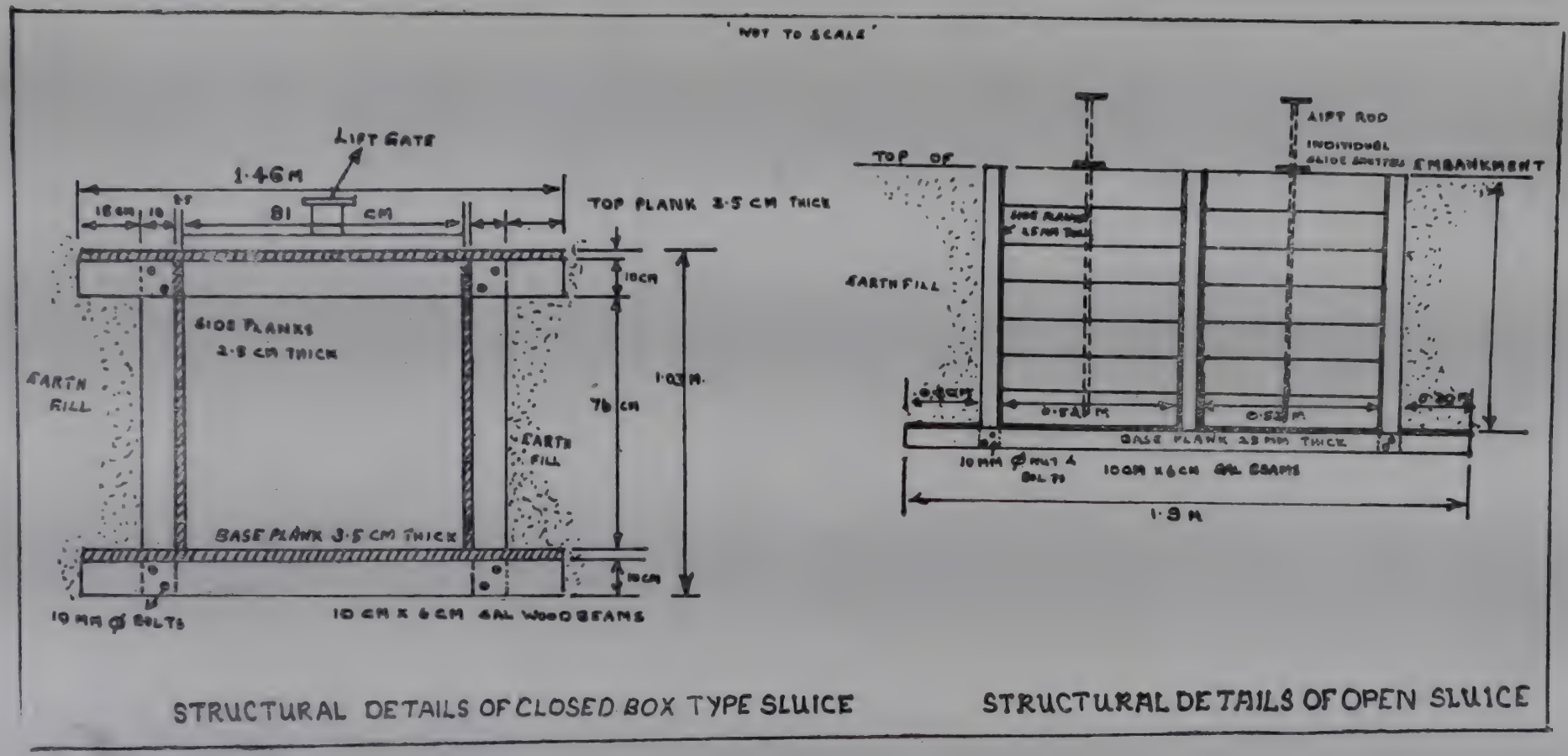

Fig 2. Structural details of sluice

H.W.O.S.T.	Velocity of flow (M/sec)	Discharge (Cum/sec)	Vent area of the sluice at full opening (Sqm)	Sill level of the sluice in relation to mean sea level.
+2.05 m	0.15 0.30 0.46 0.51 0.40 0.15	0.02 0.10 0.31 1.12 1.33 1.41	0.69	+0.52 m

With the above general rate of discharge through a sluice opening having a vent area of 0.69 sq.m., i. e. internal measurements, 91 cm base width by 76 cm clear height of the opening, it has been possible to inundate a brackishwater impoundment of 1.22 ha area to a depth of 0.50 m during ordinary spring tides.

Workability and Results.

It has been observed from the experiments conducted with the conventional closed box type sluice at the Brackishwater fish farm of the Central Inland Fisheries Research Institute at Bakkhali in Lower Sunderbans that this type of sluice has a score of demerits, and it fails to satisfy basic requirements for maintaining an ideal environment in the brackishwater fish and prawn pond (Mukherjee, 1977). The discharge through the sluice remains steady at the initial phase of tide but in the rising phase of tide, and particularly when the tide water level is above the crest of the sluice, the velocity increase high, and a turbulence in the flow is formed which discharges into the pond with a high flow energy. The dynamic action of the discharging water erodes and scours the pond bed.

Furthermore as most of the young shrimps which inhabit the surface layer of tide water and are carried by the flood tide, get scared while coming across the turbulence at the sluice mouth, and refrain from being carried into the pond.

Again in fully submerged condition, this type of sluice draws water only from the bottom layer of the flood tide wnich although is rich in nutrient contents but carries a good amount of bed silt which gets deposited on the pond bed and reduces the storage capacity of the pond.

Hence this type of sluice inlet is unsuitable for shrimp culture pond and requires some modifications in its structural design.

Open top sluice.

The demerits of the closed box type sluice may be removed by bringing a change in its structural design to make it an open type sluice i.e. providing no roof cover to the sluice, two vertical

walls of the sluice to support the earth load of the embankment and a base floor for smooth flow of water (Fig. 2). Experiments have been actually conducted with an open type wooden sluice inlet to function as a primary control gate, installed at the mouth of main feeder canal which supplies water to a row of mullet and shrimp ponds on its both sides at the Brackishwater Experimental Fish Farm of Central Inland Fisheries Research Institute at Kakdwip,

This type of sluice has given satisfactory results, and may be found suitable as a water control gate for shrimp ponds.

Structural Details and Construction.

Inside measurements of the sluice control gate are:- width = 0.52 m; height = 1 05 m; and length = 2.72 m which being also the full width of embankment supported by the sluice. The sluice has two compartments positioned side by side with a common wooden partition in between the two compartments.

Two sides of the sluice supporting the embankment load, partitions and base are all 25 mm thick Sal wood planks which are firmly connected with the supporting frames composed of 10 cm x 6 cm Sal wood beams with 10 mm dia. nuts and bolts. Frames are spaced at 75 cm apart and all the frames are projected for a length of 30 cm. on both sides of the sluice for supporting extra earth load to counteract the uplift pressure of water from underneath the floor of the sluice. Similarly floor planks a.e extended for a length of 60 cm. or both ends of thes luice for ensuring easy and smooth discharge. Wooden stakes or bamboo poles are driven into the soil at a very close spacing on the toe-line of embankment near the sluice openings to check scour and prevent soil loss owing to impact of tidal flow on the side slopes of the embankment.

Control Devices.

Arrangement for controlling the flow is maintained at both ends of the sluice. At the down-stream end i.e., supply canal face, the flow is controlled with the help of individual drop shutters or slide planks each 15 cm in width which freely rests one on another. The shutters can be held in any position with the operation of the lifting rod. The other end of the sluice which opens into the pond, is provided with screen gate that prevents the entry of predators carried along with the tide water and also obstruct the escaping of shrimp from the pond during the low tide. The gates are opened when the flood tide level is 45 cm above the sluice floor as the shrimps then find it difficult to escape from the pond against this head of water.

Workability and Results.

Structural pattern of this type of sluice enables the tidal waters to flow smoothly info the pond without any turbulence. The flow through the sluice is always released directly into pond as free discharge. The velocity of tidal flow through the sluice is controlled by regulat-

ing the adjustable shutters and as the shutters can be held in any position, discharge through the sluice can be regulated through a predetermined vent area which thus reduces the turbulence and erosive flow energy of discharging ide water on the pond bed.

Surface layer of tide water which carries less silt can be taken into the pond and the bottom layer of tide water which brings along with it a good amount of coarse bed silt is prevented from getting access into the fish pond by dropping down the shutters of the sluice upto that depth of water level,

Openings of the sluice being large, total volume of water admitted in a tidal cycle is sufficient to fill the ponds upto its optimum water level. Similarly, the pond can be completely emptied at low tide as the sluice is constructed in relation to tidal levels.

Since the top of the sluice is open any defect or flaw in the structure is easily detected and attended to instantly. Coaltar which must be applied in thick coats all over the surface and parts of the sluice at least twice in a year, can be conveniently done so as the structure is open. A properly maintained wooden sluice structure can give satisfactory performance for a number of year.

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CONSTRUCTION AND MAINTENANCE OF SHRIMP FARMS MATERIALS USED IN THE CONSTRUCTION OF AQUACULTURE SYSTEMS

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Introduction.

Aquaculture is the production, processing, transporation and marketting of biological organisms from aquatic systems. Today aquaculture is practiced to some extent in every country in the world with the possible exception of the Antarctic continent.

A very wide variety of materials are at present in use in the construction of aquaculture systems required in shrimp farming. There are several possible approaches to increasing the productivity of aquatic systems. These approaches almost always can be classified into one of the three groups : (1) open system, (2) semiclosed systems, and (3) closed systems.

Open system is the oldest and a natural system without any or very little man made modifications. On account of its low cost and limited management requirments, it is most popular. Recovery of the resource is slow, if depletion ever occurs. Depending on the desired outcome, management can be very simple or very complex. When we attempt to obtain maximum sustainable yield then the mannaement becomes very complex. The open system is commonly practised everywhere in the world of aquaculture e. g. India, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Thailand, Taiwan, Vietnam and the U. S. A. In India it is very well developed in Bengal *(bheries)* and Kerala (*Pokkali* fields) and is in vogue in most of the maritime states, in varying degrees.

Semiclosed system is characterised by the use of natural waters, which are allowed to pass through the system, control can be exercised over the variables such as water temperature, water volume and velocity, predators and diseases. Many semiclcsed systems require filtration and purification of water. Higher, capital is required to get good returns from the facilities. It is highly successful in the culture of sports fish in U. S. A. and elsewhere.

Closed system allows environmental parameters to be closely controlled. The water is seldom, if ever, exchanged with sources outside the system. Water is circulated by pumps and other devices. Water temperature, one of the most critical for poikolothermic orga-

nisms, can be controlled much more economically in a closed system than in a semiclosed system. Space required is smallest. Cost is very high, but with scientific care and the great art of management, the returns are highly rewarding. At present practiced mostly in Japan, Korea, Taiwan, and the U. S. A. Japan has successfully produced about 22,000 kg per hectare in 6 months on experimental basis of *Penaeus japonicus*. At an average minimum price of Rs. 45 per kg. the realisation works out to the fantastic amount of Rs. 9.9 lakhs. If the Japanese could master the great art of management with scientific care at such high level, surely we can easily reach the level of atleast 20% in the initial stages. Even this will come to Rs. 1.8 lakhs. As we have already acquired the necessary know-how in respect of our fast growing penaeid shrimps, we should not waste even a single day in implementing shrimp culture by the Japanese way.

All farm ponds are mostly man made, either by embankment or by excavation. Embankment ponds are the most common ponds used for aquaculture, primarily because they can be constructed in a great range of topographical conditions. They have other significant advantages over excavated ponds. Some ponds may require excavations and embankment to achieve the desired water holding capacity.

The difference between tanks and ponds is primarily one of size and perhaps materials of construction. Ponds are larger and typically of earthen construction, whereas tanks are relatively smaller and constructed of concrete and a wide variety of other suitable materials. The variety of tanks used for culture of aquatic organisms is endless.

Some of the materials used in the construction of tanks:

1. Concrete: It is a mixture of cement. sand, and gravel, with water in varying proportions according to the use which is to be made of it. It is widely used for larger culture tanks. It is a durable and low cost material. It can be easily formed into the desired shape. Interior surfaces of concrete tanks can be made fairly smooth. Uncoated concrete is satisfactory for most aquacultural work. Where bacterial harborage must be avoided, particularly in closed system aquaculture, use of a suitable epoxy * resin or some nontoxic sealer is a must.

* EPOXY SYSTEM:

The conventional epoxy systems have been either solvent based or solvent free, but not water based. They encounter problems of toxicity, skin irritation and flammability. Whereas Aqua Epoxy formulation are nonflammable, odourless, relatively non-toxic and prefer damp substracts. They can be applied on fresh uncured concrete. Two coats of 'Aqua Epoxy 300' with dry film thickness of 6 ml each would cost about Rs. 2/- per square foot. They are now available in India from a Bombay firm and are manufactured in collaboration with an American firm. The quality is standard and at present are widely used and in great demand by the building industry.

Synthetics: A very wide variety of synthetics are in use.

(a) Fiberglass: This material is probably most suited for culture tank construction. It is light, strong reasonably priced, and it is inert to fresh water and salt water. Also it can be moulded to most desired shapes. Fiberglass is strongest in tension loading in circular tank walls. Cast fiberglass tanks may contain fiberglass matting and this mat material must be completely covered with epoxy resins.

(b) Vinyl : This flexible plastic is widely used for swimming pool liners and other applications calling for flexibility and essentially zero permeability to water. Relatively it is inexpensive, smooth (thus preventing damage to delicate larval stages,), and easily cleaned. In fish and shrimp culture, readily available children's wading and swimming pools may be conveniently used to culture and hold aquatic organisms. They are cheap, readily available in different sizes, and can be conveniently stored in limited space. They are not very durable. Vinyl liners have been used to seal ponds constructed in permeable soils.

(c) Rubber : Rubber and other materials of similar qualities are more commonly used as liners for sealing ponds in permeable soils because of cheaper cost, service conditions, and availability factors.

(d) Polyethylene : It is similar in properties to vinyl but does not elongate as much. It is also widely used for making an impermeable liner for low cost rigid structures. It is available in rolls of 75 metre long and 6 metre wide packings. Since it can be easily purchased in many thicknesses, the necessary materials can be selected based on user conditions.

(e) Acrylic: This material is widely used for experimental purposes in aquaculture. Plexiglass acrylic plastic has limited flexibility below about 0.35 cm thickness. At greater thicknesses, it is essentially rigid. Clear acrylics allow visual observations of the desired operation. They are available in a variety of colours. Acrylics can be drilled, taped, and worked with machine tools to desired shapes and dimensions. They scratch relatively easily but will not shatter like glass. Solvent bonding can be done or special glues designed for use of acrylics may be used conveniently. They are inert to fresh water and salt water. Acrylics swell somewhat when exposed to high humi dity. They tend to be too expensive for tank construction in commercial acquaculture, except in limited applications.

(f) Polypropylene : Tanks made from polypropylene are available from many suppliers in stock sizes upto atleast 1,500 liters. Larger sizes can be had on special bulk order. Larger tanks tend to be more expensive than fibreglass tanks of similar construction. Since glueing to it is very difficult, if not impossible, mechanical fitting attachments may be used conveniently. It is also inert to both fresh water and sea water.

(g) Polyvinyl chloride (PVC) : Stuctural support must be provided for all but the smallest tanks made from PVC. Primary use of PVC is not for tank con-

struction, but for plumbing in salt water systems. PVC plumbing is probably the cheapest material for use in salt water systems. It is inert to both fresh and salt waters.

Metals : some of the metals in use are:-

(a) Steel : Essentially an alloy of iron and carbon. Contains less than 2% carbon, less than 1% manganese, and small amounts of silicon, phosphorus, sulphur, and oxygen. It can be safely used for tank construction for fresh water systems, although rust will develop. With proper coatings, steel will provide good service in both fresh water and salt water systems. Steel surely, is the best choice in salt water systems. However, steel often is the least expensive means of providing tank structural support.

(b) Aluminium : It is a light ductile metal with good resistance to corrosion. Aluminium will serve very well in fresh water, and certain aluminium alloys will provide good life in salt water systems. In closed systems all metals should be used with great care because even limited corrosion over long periods can cause an ion build up in the culture water to the detriment of the organisms cultured.

(c) Stainless steel : Corrosion resistant steel is of a wide variety of composition, but always containing a high percentage (8 to 25%) of chromium. It is highly resistant to corrosive attacks by organic acids, weak mineral acids, atmospheric oxidation, etc. It will provide very good service in fresh water and fairly good service in salt water. In closed salt water systems even the corrosion resistant 300 series stainless steel will corrode in the long run. Stainless steel is expensive, but for screens and similar applications it is a good alternative if plastic materials are not available or do not provide the necessary strength.

Conclusion :

Aquatic resources of the world are enormous. About 71% of the earth's surface is known to be covered with water. More than 97% of the water in the world is in the oceans. Aquatic environments hardly supply about 3% of the world's food supply, while aquaculture supplies only about 0.25 to 0.30% equaling 5 to 6 million tonnes. Shrimps contribute about 50,000 tonnes viz. hardly 1% of aquacultured organisms. There being a definite limit to the sustainable catch available from the capture fisheries production, we have to adopt bold steps for tapping the vast potential of aquaculture. Aquaculture production depends on the level of effort and the cultural practices.

In India we are on the threshold of revolutioning aquacultural practices. With the present exports of marine products to the tune of rupees 200 crores per annum and ambitious plans to step upto nearly 530 crores per annum by 1982-83 we have to adopt on war footing all systems of aquaculture on mass scale for shrimp and lobster culture so as to achieve and/or get nearer to achieving our cherished national targets.

ECONOMICAL IMPLICATION OF SHRIMP FARMING

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Stabilisation of the yield of marine shrimps from the 40 fathom zone of the shelf waters despite the increase in efforts of capture has made it imperative to seek alternative sources to augment shrimp production. Theoretically there exist two directions for further developmnt: a) extension of capture fishery technology to shelf areas beyond 40 fathome and b) experimentation with culture fishery on the shore itself. In the last few years some efforts have been made in both these directions.

While the exploratory fishing by deep sea trawlers indicated certain resources of finfish in the sea beyond 40 fathoms, the marine penaeid shrimps, which form the back-bone of the offshore trawling industry have not been located at sufficient density to warrant profitable exploitaion. Also, the capture fishery of deeper waters has created several problems, legal, social and financial, which remain hitherto unsolved (Gokhale, 1978)

Although, the culture fishery has a long history in India that of marine environment has a much recent origin. Experimental cultivation of penaeid shrimps is stiil more recent and is, by and large, restricted to the research institutes and departments along the east and west coast of India (e. g. C. M. F. R. I. Cochin; C. I. F. R. I. W. Bangal; C. I. F. E, Kakinada; N. I. O., Panaji; Konken Agricultural University, Ratnagiri, etc). From the periodically published reports of such institutions it would appear that shrimp cultivation has already progressed from "know-why" to "know-how" and has reached the status of "industrial technology". And yet the fact remains that not a single commercial farm has started operation in this country so far.

Production potential of shrimp farming is formidable. It is estimated that these abound nearly 7 million hectares of brackishwater land in the country which are either totally unutilsed or grossly under-utilised (Durve, 1975). Experience of several south-east and far-east countries in mariculture has shown that such areas are immensely suitable for shrimp farming (Milne, 1972; Bardach, et al, 1972; Shigueno, 1975) Assuming 50% development of above land for shrimp farming and taking a very conservative estimate of the yield of 250 kg per hectare the annual production by cultivation comes to nearly 0.125 million tons of shrlmps which is more than the present total landings of the country (C. M. F. R. I.,

1977). In other words potential exists of doubling the present shrimp production by application of cultivation technology.

If such is the case why has not shrimp farming developed into an industry so far? Like any other business venture the reason could be either that this project has not been given sufficient thought to or that the project has been well thought over and shelved as unappealing. We are of the opinion that while the industry was apprised of the benefits of shrlmp farming the specific details of the technology and the financial implications have never been provided. Of the two directions mentioned earlier for increase in shrimp production the industry possibly felt that the second was uncertain and resorted to the first where the technology was already or at least allegedly known.

Shrimp farming is indeed a new concept in fisheries. As the word "farming" implies it is a collective operation of the mechanics and chemistry of the cultivation medium, seed production and sowing, crop management and protection, harvesting and post-harvesting activities. With specific relevance to shrimp-farming the above acitivities can be separated in four main operations:

i) farm site development and preparation

ii) shrimp seed production/procurement

iii) cultivation operation,

iv) harvesting and marketing.

It is possible to follow the cash-flow through these operations by costing each operation.

We wish to present here our contemplations of shrimp farming, particularly in this regard. The concept presented is by no means intended to be taken as the "central dogma" of shrimp-farming, rigid and perfect. It merely reflects our conclusions after a decade of experience with the related aspects of this fieid. The presentation is meant to give the future entrepreneures an idea of the financial outlay involved which, we beileve, will be the crucial point for the development of this enterprise either in thepublic sector or in the private sector.

Shrimp farming may be considered as the periodic rotation of a wheel with one cycle consisting of one crop. The wheel is ready for rotation with development of the farm site. The cycle begins with introduction of shrimp-seed i. e. postlarvae of shrimp. The cycle is complete when the shrimps attain marketable size. The time and the distance travelled by the wheel is the cultivation operation. The driving force for the rotation is monetry i. e. cost of the operation. All these units can be costed and seen in financial terms. Thus we have the farm development as the capital cost and the expenditure incurred through one cycle as the recurring cost. Broad details of the recurring expenditure will be cost of management, maintenance, seed, feed and the annual depreciation and loan repaymentr. These will be the inputs per cycle. Outputs will be shrimp production and sale proceeds thereof. Debiting the recurring expenditure from this we obtain the net profit. If the net profit is obtained in this manner is better than 15% of the investment there is no reason why the

enterprise of shrimp farming should not be attractive.

Projected expenditure of shrimp farming is gives in Table I. Expenditure is calculated separately for i) 1 and 2 hectare farms suitable for a small scale family of fisherman, ii) 5 and 10 hectare farms suitable for a small-scale industry and iii) 25 and 50 hectare farm suitable for a medium scale industry. Although projections can as well be made for still larger farms we are not certain that the management of such can be done by a single unit. The income-expenditure statement, phased over five years of operation of these farm is given in Table II. The gross returns are calculated on the basis of shrimp production of 1 ton per hectare at a selling price of Rs. 30/-per kg. Seed stocking is assumed to be at the rate of 1,00,000 post-larvae per hectare with the seed cost of Rs. 50/-per thousand. Survival of the harvest is considered to be 33% when the size attained by shrimps will be 30 gm.

Considering Table I it is at once apparent that the total outlay increases with increase in farm hectarage. However, cost of development of a 10 hectare farm will not be ten times the cost of 1

TABLE - I

projected expenditure (in lakh of Rs) of Shrimp Farming

Item of Expenditure	Farm hacterage					
	1 h.	2h.	5h.	10h.	25h.	50h.
1. *CAPITAL EXPENDITURE*	0.3	0.5	1.15	3.35	6.7	12.0
11. *RECURRING EXPENDITURE*						
(A) *STAFF* (Per year)	--	--	0.23	0.40	0.69	1.11
(B) *Maintenance & Repairs* (per year)	0.04	0.06	0.08	0.15	0.50	0.75
(C) *Cultivation & operation* (per crop)	0.07	0.14	0.35	0.70	1.85	3.65
(D) *Depreciation/Loan Repayment*	0.06	1.10	0.23	0.67	1.34	2.40
TOTAL RECURRING	0.17	0.30	0.89	1.92	4.38	7.91

TABLE - II

Phasing of Expenditure and Income

Sr. No.	Farm Hectarage	Year	Expenditure					Income	
			Capital cost	Recurring cost				Returns	
				Staff	M. & R.	C. O.	D. / L. R.	Sale proceeds	Net profit
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1.	1 ha	1	0.30	–	–	–	0.06	–	(—)0.0
		2	–	–	0.02	0.07	0.06	0.30	0.15
		3	–	–	0.04	0.07	0.06	0.30	0.13
		4	–	–	0.04	0.07	0.06	0.30	0.13
		5	–	–	0.04	0.07	0.06	0.30	0.13
		Total	0.30	-	0.14	0.28	0.30	1.20	0.48
	Grand total		0.30	-		0.72		1.20	0.48
2.	2 ha	1	0.50	–	-	–	0.10	–	(—)0.10
		2	-	–	0.03	0.14	0.10	0.60	0.33
		3	–	–	0.06	0.14	0.10	0.60	0.30
		4	–	-	0.06	0.14	0.10	0.60	0.30
		5	-	-	0.06	0.14	0.10	0.60	0.30
		Total	0.50	–	0.21	0.56	0.50	2.40	1.13
	Grand total		0.50	-		1.27		2.40	1.13
3.	5 ha	1	1.15	0.15	-	-	0.23	-	(—)0.38
		2	–	0.23	0.05	0.35	0.23	1.50	0.64
		3	-	0.23	0.08	0.35	0.23	1.50	0.61
		4	-	0.23	0.08	0.35	0.23	1.50	0.61
		5	-	0.23	0.08	0.35	0.23	1.50	0.61
		Total	1.15	1.07	0.29	1.40	1.15	6.0	2.09
	Grand total		1.15		3.91			6.0	2.09

contd/-

4.	10 ha	1	2.0	0.15	-		-	0.40	-	(—)0.55
		2	1.35	0.40	0.10	0.35	0.7375	1.50	(—)0.0875
		3	–	0.40	0.15	0.70	0.7375	3.0	1.0125
		4	-	0.40	0.15	0.70	0.7375	3.0	1.0125
		5	-	0.40	0.15	0.70	0.7375	3.0	1.0125
		Total	3.35	1.75	0.55	2.45	3.35	10.50	2.40
	Grand total		3.35		8.10			10.50	2.40
5.	25 ha	1	5.0	0.25	-	-	1.0	-	(–)1.25
		2	1.70	0.69	0.25	1.0	1.425	3.50	(–)0.135
		3	–	0.69	0.50	1.85	1.425	7.50	3.04
		4	–	0.69	0.50	1.85	1.42	7.50	3.04
		5	-	0.69	0.50	1.85	1.42	7.50	3.04
		Total	6.70	3.01	1.75	6.55	6.70	26.0	7.735
	Grand total		6.70		18.01			26.0	7.735
6.	50 ha	1	8.0	0.40	–	–	1.60	–	(-)2.0
		2	4.0	1.11	0.50	1.0	2.60	3.50	(–)1.71
		3	–	1.11	0.75	3.65	2.60	15.0	6.89
		4	–	1.11	0.75	3.65	2.60	15.0	6.89
		5	–	1.11	0.75	3.65	2.60	15.0	6.89
		Total	12.0	4.84	2.75	11.95	12.0	48.50	16.96
	Grand total		12.0		31.54			48.50	16.96

M & R - Maintenance and Repairs., C. O. - Cultiviation and Operation
D/L.R. - Depreciation and loan repayment.

hectare farm. The length of the primary bund, a main item of capital expenditure, increases from 500 net for 1 hectare to only about 3000 net for 50 hectare farm is in support of this. Cost of cultivation operation will increase proportionately with farm hectarage with possible reduction in cost of feed. As 1 and 2 hectare farms will be managed by fishermen family no expenditure will be required on staff. It follows that with increase in farm hectarage expenditure on management will increase. The expenditure shown for the bigger size farms in Table I is the minimum that will be required for staffing. It is assumed that the capital investment should be returned within five years period. This gives a recurring expenditure of 20% of the capital every year.

Phasing of the farm economics over five years of operation shows the first year as spent in construction of farm (Table

II) and hence no returns from sale proceeds of the farm produce can be anticipated. Depending upon the size of the farm either full capacity or half the capacity of the farm production can be anticipated during the second year. From the third year onwards farm should work at full capacity. The total net profit after five years are shown in the last column of the statement. The average annual returns on the investment in this way comes to 32% for 1 hectare farm, 45% for 2 hectare farm, 36% for 5 hectare farm, 14% for 10 hectare farm, 23% for 25 hectare farm and 26% for 50 hectare farm. The decrease in the rate of profit with increasing expenditure on management increase in the farm hectarage is largely due to the increasing expenditure on management of the items of recurring expenditure, all items except cultivation operation are on the annual basis. On the other hand gross returns from the sale proceeds are directly related to the cultivation operation. In other words if two crops are taken per year there is 100% increase in sale proceeds but only about 30% increase in recurring cost. The number of crops per year will depend upon the growth rate of the candidate species used for cultivation. The estimate of net profit presented earlier were based on the growth rate of white shrimp *Penaeus merguiensis*. This species, like other species of the genus *Penaeus* which grows to 30gm in 10 to 11 months (Chavan, 1978 unpublished). However, it can as well be marketed at 20 gm size which is attained in 6 to 7 months. Two crops are directly possible in this way. The recent work of Parker *et al*. (1974) on intensive culture in modular farming has shown that it is possible to obtain 6 tons of shrimps per hectare per year by taking five crops. The production estimate of I ton per hectare assumed in the present paper in thus not unrealistic and the work of Parker *et al*. (1974) shows that shrimp farming can be much more profitable by application of intensive technology.

A word of apprehension has to be said about the risks involved in shrimp farming. Webber (1973) has adequately ennumerated these for aquaculture in general. The main risk is biological. This includes diseases and parasites, seed production, predation and competition, inventory control, nutrition and natural productivity. Since shrimp farming is a much controlled operation it will not be impossible to take adequate measures on the spot with the help of sound technical consultancy.

One aspect, however, needs to be taken very seriously. This is seed production. Seed requirement of a shrimp farm can be quite formidable. As mentioned earlier about 1,00,000 seed will be required per hectare per crop. If there are to be more than one crop per year this much amount of seed will be required at specific times through out the year. While seed is available in nature specific precurement of the postlarvae of a desired species in a desired quantity at a desired time is simply not procurable from this resource. To give an example, in Maharashtra there exist about 40,000 hectares of brackishwater lands. Reverting back to the earlier estimate of 50% development for shrimp farming the 20,000 hectares will require about 2 billions of shrimp seed.

ECONOMICAL IMPLICATION

To depend upon the natural source for the procurement of this is totally impossible. The seed, therefore, has to be produced by artificial means.

We give in Table III the economics of a ocmmercial hatchery. Much of the expenditure projection is based on our own pilot scale shrimp hatching facility at Ratnagiri. The hatchery will depend at present at least, on natuarally occur-

TABLE - III

Economics of 2 shrimp hatchery

I.	*Capital cost*	*Rs.*
i)	Cost of land	10,000/-
ii)	Cost of construction	1,50,000/-
iii)	Water & Electricity fiting etc	40,000/-
iv)	Water filteration unit	60,000/-
v)	Rearing ponds	40,000/-
vi)	Machinery & Equipment	1,00,000/-
	Total	4,00,000/-
II.	*Recurring cost*	
i)	Staff	40,000/-
ii)	Cost of brood shrimps	6,000/-
iii)	Cost of feed	4,000/-
iv)	Cost of various Cultures	4,000/-
v)	Electricity, water charges etc	5,000/-
vi)	Depreciation & Loan repayment	80,000/-
vii)	Miscellaneous	5,000/-
	Total	1,44000,/-
III.	*Profit and Loss*	
i)	Sale of 10 million seed	5,00,000/-
ii)	Less recuring cost	1,44,000/-
iii)	Net profit	3,56,000/-

ring gravid female shrimps for reproduction. With the monsoon stoppage of fishing activity the hatchery is expected to function for 200 days. With 15 days period of larval development (Raje and Ranade, 1972) this gives about 10 to 12 cycles of operations. Each cycle is estimated to yield about one million postlarvae from this facility, giving the annual production of 10 to 12 million postlarvae. The capital and recurring costs will be Rs. 4.0 lakhs and 1.5 lakh respectively. The sale proceeds of 10 million postlarvae at the rate of Rs. 50/- per thousand amount to Rs.5.0 lakhs giving a net profit of Rs. 3.5 lakhs. After phasing the operation over five years the net annual profit will be about Rs. 2.8 lakhs which is nearly 70% annual return on investment. Accounting for various difficulties and failures by reducing the profit margin to a very pessimistic 50%, the profit rate is still a very attractive 30 to 35%.

As mentioned earlier, the economics of shrimp farming or shrimp hatchery are by no means perfect. However, we are of the opinion that they are not far unrealistic, either. In view of the benefits of shrimp farming this enterprise warrants every incentive from the government through financing bodies particularly since shrimp farming is within the means of a very small fisherman or allied unit. In view of the profit margin it is also high time that the industry gave a much more serious attention and efforts for the development of this enterprise.

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ECONOMICS OF TRADITIONAL PRAWN CULTURE PRACTICE IN KERALA WITH A NOTE ON THE ADVANTAGES OF INTENSIVE PRAWN CULTURE

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Introduction

The traditional prawn filtration *(Chemmeen Kettu)* of Central Kerala is a seasonal operation carried out in about 5117 ha of pokkali Paddy fields and other low lying areas adjoining the Vembanad Lake. Although there are several published reports on shrimp production in these fields, information on the economics of paddy and prawn cultivation is scanty. Menon (1954), Gopinath (1956) and George *et al* (1968) have estimated the average annual production of prawns in some of these paddy fields; while George (1974) has given a brief account of the economics of paddy cultivation and prawn culture. In the present paper, the data on various expenditure involved in the operations and income from the production in the traditional paddy-cum-prawn culture practices of Kerala are analysed.

Field operations.

The traditional operations in the Pokkali paddy fields of Kerala are in two phases, namely, paddy cultivation and prawn culture.

Paddy cultivation.

Paddy cultivation is carried out by the owners of the fields themselves. Due to heavy south west monsoon rainfall, the water in these fields remains almost fresh between June and October and it is during this period that paddy is cultivated. The variety of paddy used for cultivation is locally known as *pokkali* which is tolerant to salinity up to 8‰ (Muthu, 1978). Just before the onset of the monsoon the fields are drained and kept almost dry for about a week. The soil is then raked up and heaped into small mounds in the first week of May, and allowed to dry in the sun till monsoon begins. When the fields get filled up with fresh rain water, they are drained out three or four times so as to leach out the saline content of the soil. In the meanwhile, seeds are soaked in water for 12 hours and kept atleast for 5 days for germination, tied in coconut leaf baskets. Just before sowing, these seeds are again put in water for 6 hours so as to facilitate proper germination. These germinated seeds are then sown on the flattened mounds. 10 paras (80 kg) of seeds are required for sowing a field of one hactare area. On an average, the

seeds take about a month to grow to a size for transplantation. Deweeding of extraneous plants in the field is undertaken before transplantation. It is carried out by shoveling off the seedlings along with their roots and earth and distributing them uniformly in the fields after leveling. This variety of paddy requires a maximum of 120 days for growth from the time of their seeding in the field. Normally, no manure is applied for *pokkali* cultivation. As in the case of other paddy crops, better growth and production of *pokkali* paddy depend on the rainfall. Intermittent rains rather than continuous ones are found to be more favourable for the growth of the plant. Harvesting of paddy is carried out during September/ October.

Prawn culture

After the harvest of paddy, the fields are leased out to prawn farmers for a period of five months from 15th November to 15th April. The lessee of the field carry out repairs to the bunds and fixes the sluice gates for regulation of water flow in and out of the fields. During each high tide, the water is let into the field. The incoming tides bring in the prawn seed along with other organisms. During every ebb tide, a bamboo screen is kept at the inside of the sluice gate to prevent escape of seed from the field. This process is continued throughout the season. The actual fishing operation begins invariably during the first lunar phase *'Thakkom'* of December and is continued during every *'Thakkom'* till the end of the season. Fishing is carried out for 6 to 8 days around every *'Thakkom'* by fixing a conical filter net at the outer side of the sluice gate. The final fishing is done in the second week of April by cast netting, hand picking etc. after draining out the water from the fields as much as possible. It is noticed that there are wide fluctuations in the total yield of prawns from these fields from year to year.

Economics

Important items of expenditure in paddy cultivation are for the preparation of the field, cost of seed, labour charges for sowing, deweeding, transplantation and harvesting. Normally 1/8 of the harvest is set aside for wages of labourers for harvesting. Table I gives the actual expenditure for different items of paddy cultivation in a field of 16 ha area in Vypeen Island near Cochin during season, June to October 1977. The total expenditure amounted to Rs. 25,395.00, the labour charges for preparation of the field for seeding and for transplantation accounting for about 50% of the expenditure. The total expenditure per ha amounted to Rs. 1,587-20.

The yield of paddy from the field was 32,549 kg. and that of hay about 8,000 kg. The total income from the sale of paddy and hay was Rs. 36,183.00. The income per ha for paddy cultivation thus amounted to Rs. 2,261.45; the net profit being Rs. 674.25 (Table I)

TABLE - I

Economics of paddy cultivation in a 16 ha Pokkali Field at Vypeen in 1977-78.

	Rs.
I. *Expenditure*	
a. *Preparation of the field*	
i. Drying the field*	3,168-00
ii. Labour charges for making channels ** to drain out water and repair to bunds @ Rs. 11/-per head/day for 160 men.	1,760.00
iii. Labour charges for raking the field and heaping into mounds @ Rs. 12/50 per head/day for 400 men	5,000,00
b. *Pokkali cultivation*	
i. Cost of seed @ Rs. 12/- per *para* (8 kg) for 160 *paras* (1280 k g)	1,920.00
ii. Labour charges for sowing the seed @ Rs. 11/- and @ Rs. 6/50 per head/day for 32 men and 48 women.	664.00
iii. Labour charges for deweeding @ Rs. 6/50 per head/day for 400 women.	2,600.00
iv. Labour charges for transplanting the seedlings @ Rs. 12/- and Rs. 6/50 per head/day for 176 men and 592 women respectively.	5,960.00
c. *Harvesting*: Wages for labourers for harvesting (1/8 of the total yield of paddy: ie. 508.6 *paras* (4,069 kg) @ Rs. 8/50 per *para*)	4,323.00
Total :	25,395.00
Expenditure per ha:	1,587.20
II. *Income*	
i. From 4,068.6 paras (32,549 kg.) paddy @ Rs. 8/50 per *para*	34,583.00
ii. From hay	1,600.00
Total :	36,183.00
Income per ha :	2,261.45
iii. Net income per ha : Rs. 674.25	

* Usually drying of the field is done by exposing to the sun; but in several deeper fields, the water is pumped out mechanically.

** Channeling is done for easy and complete draining of salt water from the field.

TABLE - II

Economics of traditional system of prawn culture in a 16 ha Pokkali field at Vypeen during 1977-78.

1. *Expenditure (16 ha)*	*Amount* Rs.
i. Lease amount	80,000.00
ii. Maintenance of bund	1,800.00
iii. Maintenance and fixing of sluice gate @ Rs. 500/- for 6 Nos.	3,000.00
iv. Bamboo/Arecanut screens (6 Nos)	450.00
v. Sluice net:	
a. For fishing (Thoombu vala)-3 Nos	1,200.00
b. For letting in water (Etta vala)-3 Nos.	450.00
vi. Rent towards canoe @ Rs. 3/- per day for 3 canoes for 5 months	1,350.00
vii. Shed	2,800.00
viii. Wages @ Rs. 250/- pm for 4 labourers and supervision charges @ Rs. 450/-pm.	7,250.00
ix. Miscellaneous	1,500.00
Total	99,800.00
Expenditure per ha	6,237.50

II *Production and income (16 ha)*

	Quantity (Kg)	*Rate/Kg* Rs.	*Amount* Rs.
i. *P. indicus (Naran)*	4,100	20.00	82,000.00
ii. *P. monodon (Kara)*	67	40.00	2,680.00
iii. *M. dobsoni (Thelly)*	7,194	3.25	23,380.50
iv. *M. monoceros (Choodan)*	393	5.50	2,161.50
Total	11,754		1,10,222.00
Per ha	734.6 Kg		6,888.87

III. i. Net income for 16 ha : Rs. 10,422.00
ii. Net income per ha : Rs. 651.37

The amount spent on prawn culture and the income realised from the same field are given in Table II. The field was taken on lease for Rs. 80,000.00. The main operational expenditure includes maintenance of bunds and sluice gates, cost of fishing nets, rent of canoes. construction of shed for watch and ward personnel and other wages. The actual total expenditure of these and other miscellaneous items amounted to Rs. 99,800.00

The quantity of prawns, constituted by 53.3% of *Matapenaeus dobsoni* (Thelly) 42.5% *Penaeus indicus* (Naran), 3.5% *M. monoceros* (Choodan) and 0.7% *P. monodon* (Kara), was 734.6 kg. per ha. This yield realised an income of Rs. 6,888.87 per ha as against an expenditure of Rs. 6,237.50 with a net profit of Rs. 651.37. The combined expenditure for paddy cultivation and prawn culture per ha amounted to Rs. 7,554.50 and income to Rs. 8,880.12. Thus the net income from both paddy and prawn culture operations was Rs. 1,325.62.

Intensive Prawn Culture

The traditional practice of prawn culture has the following disadvantages:

i. Environmental factors cannot be controlled.

ii. Stocking is indiscriminate-neither the species nor the number stocked can be controlled,

iii. Stocking procedure enables entry of predators and undesirable species.

iv. The prawns are impounded in the field only for short periods and as such they are not often allowed to attain better marketable sizes.

v. The quality and quantity of the prawn catch, at no time, can be predicted.

The Central Marine Fisheries Research Institute has evaluated the above practice and suggested an improved technique of culture involving stocking of selected species of prawns which grow fast, regular monitoring of the stocked species and to culture them for longer periods of 3 to 4 months before harvest. It has been shown that by following this system, not only the yield could be enhanced but also the quality of the product improved to obtain higher unit price.

In order to test the economic viability of this culture operation and propagate the same among the prawn farmers of Cochin region, a Co-operative Intensive Prawn Farming Project has been initiated in January 1978, in a 6.36 ha/3 pond sector of the Narakkal fish farm of the Kerala State Department of Fisheries. This is a collaborative project with the Marine Products Export Development Authority, Cochin and the Department of Fisheries, Government of Kerala, jointly financing it and the Central Marine Fisheries Research Institute, Cochin providing the technical expertise.

The actual culture operations under the project were commenced in February 1978. After improving the site, juveniles of *Naran (P. indicus)* (31 - 50 mm) were collected from the adjacent back-

water canals and 40,000 were stocked in a one hectare pond. The juveniles of *Kara* (*P. monodon*) and *Thelly* (*M. dobsoni*) obtained while collecting the seeds of Naran, were also stocked in the pond. The water conditions in the seed pond and the growth of the stocked prawns were regularly monitored. After a period of 105 days of growth, *Naran* attained a marketable size of 120-150 mm/17 gm. The harvest amounted to 595.05 kg of prawns, comprising 521 Kg of *Naran*, 5.05 kg of *Kara* and 69.0 kg of *Thelly*. The recovery of *Naran* from the pond was about 75%. The yield of prawns realised a sum of Rs.14,494.18.

Remarks

The average production of prawns in a 16 ha seasonal field at Vypean was 735 kg per ha. The prawn catches are invariably dominated by the smaller species, *Thelly* which fetch very low price. The catches of the bigger species, *Naran* obtained from these culture operations contribute to about 30-40% only and do not realise high price as majority of them belong to smaller size groups. Thus the production as well as income from these operations are very low. The results of intensive prawn culture carried out under the project have shown that a catch of 521 kg of almost uniform size *Naran*, which forms about 90% of the total prawn catch, could be obtained within a period of $3\frac{1}{2}$ months. By proper management of the operation, it could be possible to take atleast two such harvests in an year in the seasonal fields and three harvests in the perennial fields and obtain an yield of 1,040 – 1,560 kg of *Naran* per ha/year. Thus intensive prawn culture would be definitely more remunerative than the traditional culture. It is therefore advocated that the present system of culture in the paddy fields be improved to undertake a crop of paddy in the monsoon months and thereafter to stock the fields with fast growing species of prawns such as *Naran* and *Kara*, to grow them for 3 to 4 months when they reach marketable sizes. Cultivation of paddy must be continued as it would help to increase the biological productivity of the fields since the paddy stumps left after the harvest of paddy decompose and act as natural fertilizer for the growth of micro-organisms which form ideal food for the prawns in the same field.

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ECONOMICS OF SHRIMP FARMING IN KAKINADA AREA

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The economic viability and technical feasibility of any project is first looked before taking up any venture on a commercial scale by any organisation, as a business by any entrepreneur or as a profession by any individual. It might be the concern of the Government or charitable trust to patronise a scheme, even if it is not economically viable, on various considerations like creating employment opportunities, production of nutritious and proteinous foods, earning foreign exchanges or as a research organisation in the hope of getting good results in future. Any project that is not self supporting or dividend yielding would not survive for long.

When we come to economics fish culture it is a difficult task to project and focuss the figures. In a developing field like brackish water fish and shrimp culture, it is much more difficult because the data available is limited in a Government organisation which also carryout multifarious activities like research, demonstrations, training and other unproductive works. The private organisations and individuals whose main concern is business, the economics could be known clearly but here again the actual figures are some times not revealed for fear of taxation etc. Thus we are, at present, in a position to take into account the experiences gained mostly by government Fish. Farms and few entrepraneurs. In working out the economics in fish culture the expenditure on the following items in terms of Unit area per annum are taken into account. 1. Capital invested 2. recurring expenditure including the cost incurred in man power actually engaged for the purpose. 3. total yield and gross receipts 4. net income. The rate of return on investment will indicate the real achievement of an enterprise which can be campared with similar other activities.

Brackishwater Fish and Shrimp Culture and economics: The Brackishwater Fish Farm of Central Institute of Fisheries Education Kakinada is the Brackishwater field training centre of Central Institute of Fisheries Education, Bombay and its constituent centres, to carryout the training programmes and operational research at the Farm. The culture tech-

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niques are followed on a scientific basis. Certain tangible results were being achieved since 1973–74. Mixed culture of fish and prawn was practised, The ponds generally manured with raw cattle dung and super phosphate in the initial stages. Occasionally phased manuring is resorted. Very rarely artificial feeding with ground nut oil cake and rice bran is given in small quantities for a few ponds when they are found in unproductive condition. The tide water was allowed to enter the ponds as much as required. A production of 2000 Kg. of fish (Chanos and mullets plus 260 Kg. of prawns) *(P. monodon* and *P. indicus)* per hectare per annum was being obtained. With artificial feeding the production has shown further upward trend. It is proposed to present these figures with reference to other existing costs in and around Kakinada.

Economics of fish and prawn culture:

The calculation are given per hectare rates.

Capital investment

1.	Cost ofland	Rs. 2,500/–(Rs.1000 to 2500 prevailing rate)
2.	Cost of construction	Rs.25,000/–*
3.	Cost of building & Sluices	Rs. 2500/–onwards
	Total	Rs.30,000/–

Recurring costs :

1.	Cost of fish and prawn seed-(stocking rate of fish seed 5000 and prawn seed 15000 to 20000)	Rs. 400/–
2.	Manures 2500 Kg raw cattle dung and 250Kg. super phosphate	Rs. 225/–
3.	Depreciation value of nets and equipments Etc	Rs. 500/–
4.	Cost on wages for 3 persons at Rs.6/- per day for one year	Rs. 6500/–
5.	Miscellaneous contigencies	Rs. 375/–
	Total	Rs. 8000/–

Income.

2000 Kg of fish sold at Rs.4/-	Rs. 8,000/–
250 Kg. of prawn at Rs. 45/-	Rs.11,250/–
Total	Rs.19,250/–
Net profit (Rs. 19,250/—8,000/-):	Rs.11,250/–

A profit of Rs.11,250 on a capital investment of Rs.30,000/-works out to 37.5% of dividends.

* Varying from Rs. 10,000 onwards depending upon the elevation of site.

The proportionate cost of construction of sluice, buildings would come down considerably. Similarly with the increase of pond area the personnel required would be proportionately less and the same personnel can be engaged for seed collection and thus the seed collection charges also will be reduced, There is scope for increase in production of fish and prawn with use of artificial feeding of fish and prawn and paying better attention with provision of man power shown per hectare area and change of cropping pattern of two crops per aunum particularly in case of prawn culture which has been just started. The pond bunds could be used for coconut plantation etc. which will yield some more revenue.

The results shown from Govt. Farms at Kakdwip and Madras are more encouraging.

Another example of brackish water farming taken up at Sri Krishna Salt Pan at Vadacheepuripalli near Visakpatnam by an entrepreneur under the guidance of this author has been shown. The culture period was Dec. '77 to April '78 (5 months) in an area of about 50 hectares.

Total amount spent for strengthening of bunds, repairs to sluice gates, shutters and screens engaging man power including seed collection, stocking, following management techniques, watch and ward harvesting charges and miscellanous expenditure was around Rs.40,000/–

Total quantity of prawn harvested was about 1500Kgs, out of about less than half the area of culture ponds and 12,500 Kgs. of fish were also harvested. An amount of Rs.40,000/- was realised from the sale of fish and prawns. Due to certain difficulties more than half the area of 50 hectares taken up for culture could not be harvested before the salinity went up beyond 50 ppt. Hence there was a total loss of prawns from these areas. Under similar condition the quantity of fairly grown 12,000 Kgs. of fish fetched only around Rs. 12,000. The prawns was sold at Rs.20 to 40/Kilogram to exporters. Thus the venture of fish and prawn culture in salt pans shows its economic viability.

PRELIMINARY EXPERIMENTS IN PRAWN CULTURE AT SANTHOME BRACKISHWATER FARM, MADRAS

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Introduction

Though significant advances have been made in the culture of prawns in many parts of the world, not much progress has been achieved in India. In the Sunderbans of West Bengal and in the extensive backwaters of Kerala, traditional forms of prawn culture have been practised for decades. In these impoundments, no scientific stocking and management have been attempted and prawns and fishes are held together and often yields have been considarable (Gopinath, 1956). Presently, attempts are being made in the maritime states of India to culture prawns scientifically in brackishwater ponds. Under the All India Co-ordinated Research Project on Brackishwater Fish Farming, of the Central Inland Fisheries Research Institute Barrackpore, shrimp culture was organised at the Brackishwater Fish Farm Madras, from 1976 and the results obtained during the period 1976-78 are briefly reported in this paper.

Materials and methods.

Three ponds, 0.1, 1.14 and 1.24 ha respectively in area, located near the mouth of Adayar estuary, with sandy clay bottom and with 0.6 to 1.2 mm depth of water were used for raising three short term crops of prawns during the period October, 1976 to March, 1978. Tidal water was let into the ponds through sluices for 3-4 days during each spring tide. The ponds were prepared by maximum reduction of water level, followed by thorough netting and poisoning with mahua oil cake at a dose of 200 ppm. After poisoning, water level was increased to 0.2 - 0.3m and urea and super phosphate were applied. Water level was raised to 0.6 - 0.7 m after 6-7 days.

Juveniles of *P. Indicus* and *P. monodon* collected by means of Velon nets from the Adyar and Cooum estuaries and transported to the farm were segregated from other species and acclimatised overnight in the hapas fixed in the experimental ponds. The next morning, healthy juveniles were counted and stocked.

Details of the species stocked, size at stocking, period of culture etc. are given in table I. The physico-chemical conditions of the water in the ponds were determined at fortnightly intervals adopting standard procedures and data are given in Table II.

Table I

Details of stocking and harvesting of prawns in three ponds in the Santhome Farm, Madras. (1976-78)

Size of pond (ha)	1.24		0.1		1.14	
Species cultured	*Penaeus indicus*		*P. indicus*		*P. monodon*	
Stocking rate No/ha	70000		37000		20000	
Size and weight at stocking mm/g.	42.2/0.4		48.5/0.8		42.3/0.5	
Manures applied	Urea	Phosphate	Urea	Phosphate	Urea	Phosphate
Dose applied before stocking (Kg/ha)	66	33	80	20	80	20
Does after stocking 30th day (Kg/ha)	34	17	20	5	40	10
60th day (,,)	17	8	20	5	40	10
90th day (,,)	17	8	Nil	Nil	40	10
Period of rearing in days	130		70		80	
Average size and weight at harvesting	130.7/13.2		147.5/20.8		169.5/33.4	
% of recovery	32.7		91.5		79.8	
Actual quantity harvested in Kg.	374.3		70.4		586.85	
Production Kg/ha	301.8		704.0		514.7	

Table II

Average physico-chemical conditions of water in three shrimp culture ponds in Santhome Farm, Madras, during 1976-77.

	Ponds (area in ha)		
	1.24	0.1	1.14
1. Period of observation	22.10.76 to 28.01.77	12.11.77 to 20,01.78	31.12.77 to 20.03.78
2. Water temperature (°C)	23.7 to 28.3	24.2 to 28.6	24.4 to 28.7
3. pH	7.3 to 7.9	7.7 to 7.8	7.6 to 7.8
4. Salinity (ppt)	3.48 to 19.79	12.62 to 22.78	10.9 to 22.42
5. Dissolved O_2 (ppm)	3.6 to 7.8	4.2 to 8.94	3.85 to 8.43

Results and discussion.

The average size and weight attained by the prawns at harvesting; percentage of prawns recovered, actual quantity of prawns harvested and production/ha are given in Table I. While growth and production of prawns in all the three ponds were encouraging the results are not comparable as the density and stocking as well as size at stocking were different in each pond and as the fertiliser treatment also differed from pond to pond. The period of rearing was also different in the three ponds. In the 1.24 ha pond there was some overflowing and consequent drop in salinity. This might have contributed to the rather low survival in the pond. However, even though the number actually survived was relatively lesser by 50% than on the smaller 0.1 ha pond and the prawns were cultured for a much longer period than in the latter, the growth was rather limited, perhaps as a result of the fertilizer inputs.

The results of growth and survival of *P. monodon* (Sundararajan et al, 1979) are encouraging when compared with the results obtained at Kakdwip, where at a stocking density of 20,000/ha the species attained an average weight of 33.7 g. in 120 days. The rate of survival (79.8) also compares favourably with that reported by Krantz and Norris (1975).

While it has not been possible to repeat the experiments and organise year-round production, it is clear that if stocking material is available, two or even more short term crops can be harvested from the same pond and this, on the basis of production achieved in a single crop could go up to a ton or more per hectare as reported by Jhingran (1976) and Blanco (1972). The preliminary data presented in this paper show that prawn culture is quiet profitable particularly in the context of increasing price for prawns, however, on the basis of a single experiment no attempt is made to assess the costs and returns in these operations.

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EXPERIMENTS ON CAGE-CULTURE OF *MACROBRACHIUM ROSENBERGII* (DE MAN)

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Macrobrachium rosenbergii, the gaint fresh water prawn has attracted the attention of many fishery scientists, as it offers immense culture possibilities. Encouraged by the availability of *M. rosenbergii* near Ukai Dam in Surat District of Gujarat, the authors attempted cage-culture experiment with the species with a view to investigate the feasibility to produce *M. rosenbergii* on commercial scale by rearing juveniles in cages (through artificial feeding) in reservoirs and lakes.

Two cages (2 x 2 x 1.25 cu. metres) with frame of $\frac{1}{2}$" in diameter pipe. All sides of the cages were covered with monofilament cloth of 16 mesh/inch size. The cages were always kept 1 meter submerged and were stocked with 200 juveniles (of size 2.0 - 3.5cm) Average weight of juveniles was 5 gm. The juveniles obtained from Shukaltirth area situated on Narmada river of Broach District were stocked in December, 1975. The live prawns were brought in aerated polytheline bags from Shuklatirth to Ukai by road. Periodically the cages were cleaned with brush without disturbing the prawns.

"Sumula Dan" cattle feed manufactured by Sumul Diary, Surat, was fed to the prawns twice daily, in the morning and evening, @ 3% body weight. The prawns actively fed on the food given.

In the second week of September, 1976, after 9 months of stocking, the prawns in the cages were taken out. Out of 200 stocked 150 Nos., weighing 30 Kg., were recovered at the end of the experiment. The prawns had attained average size of 29 cm 1200g from the size at stocking 3 cm/5g'

The mortality in the course of experiment was only 25%. The gain in length and weight were encouraging and are indicative of a feasibility of cage culture of *M. rosenbergii* in large ponds, lakes or reservoirs.

An amount of Rs. 230.12 was estimated as net profit from the cage cufture operations as indicated below:

Cost of inputs.

1.	Cost of 1 Kg. prawns stocked	Rs. 2.00
2.	Amount spent on 81 Kg. of feed	Rs. 67.88
		Rs. 69.88

Income

Sale proceeds of 30 kg. of prawns Rs. 10/- per Kg.	Rs.	300.00
	Rs.	300.00
Net profit		67.88
	Rs.	230.12

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REARING OF *MACROBRACHIUM ROSENBERGII* IN CEMENTED POND WITH RUNNING WATER AND IN KACHHA POND WITH STAGNANT WATER

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Rearing experiments to know growth of juveniles of giant freshwater prawn, *Macrobrachium resenbergii* were carried out at the fish farms of Inland Fisheries Development Station at Ukai, (Dist. Surat) Gujarat. Two types of ponds were selected, one a kachha pond with stagnant water (area 25 x 18 square meters) and another two cemented ponds (area 15 x 20 and 20 x 50 square meters respectively). In the cemented ponds, provision for running water was made at the rate of 1/15 Cusec (3 Lit per second).

With a view to investigate whether environs of the two ponds with different construction play any role in productvity and rearing potential of *M. rosenbergii*, the present investigation was undertaken.

The evperiments have shown that both types of ponds, whether cemented or Kachha, are suitable for culture and rearing of *M. rosenbergii* juveniles

The juveniles released in the pond achieved increase in length by about 20 cms and by 100 gms in weight within nine months in kachha ponds where no running water facilities exist.

If the juveniles of same length group is released in cemented ponds with running water, and the released stock is fed with Sumul Dan–cattle feed, the increase in the weight by 120 gms and in length by 22 cms, within seven months can be achieved. This is suggestive of the significance of possibly (i) running water, (ii) cattle feed as food for growing juveniles. These factors, it appears, to have role in comparative speedy growth of the prawns. However, detailed work in this direction is essential and it is in progress.

MACROBRACHIUM MALCOLMSONII, A PROSPECTIVE COMPETITOR FOR THE JUMBO PRAWN *M. ROSENBERGII*

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Among the so-called freshwater Palaemonid prawns, the Indo–Pacific species *Macrobrachium rosenbergii* is considered to be the largest and enjoys a unique position from the point of culture and is so far without any competitive species. Besides the American species, *M. acanthurus* and *M. carcinus* wherein culture attempts have been made, from India *M. malcolmsonii* which has an appreciable fishery along the river Godavari and its tributaries in the regions of Maharashtra and Andhra, appears to be the only member of the genus which can compete fairly well with *M. rosenbergii* both from culture as well as export point of view.

Considering the distribution, *rosenbergii* though has a wider distribution in the Indo-Pacific region, is rather confined to coastal areas while *malcolmsonii* with its presently known restricted Indo-Burmese distribution has penetrated even to far inland places like Nanded (Maharashtra) which is about 800 km away from the sea and Rajamundry (Andhra) thus offering a wider scope for culture even in inland areas.

Size–wise, both species compare well, generally ranging upto 300 mm. Growth rate is comparable in both species, males growing faster than females after first year of growth.

Both species have omnivorous feeding habits but *malcolmsonii* is less fastidious and easier to maintain in captivity conditions.

Though both species have cannibalistic tendency, *malcolmsonii* is observed to resort to it very occasionally and even this can be avoided by proper feeding and providing adequate shelters particularly for freshly moulted specimens.

Like *rosonbergii*, *malcolmsonii* can be cultivated in impounded waters as has been done in the departmental tanks (Maharashtra State Fisheries) of the Vidarbha region by stocking young ones from the wild.

Both species have prolonged breeding season and can be bred easily in captivity. Also, inspite of the territorial behaviour, especially of the males during the breeding season, *malcolmsonii* does show gregarious habits and can peacefully live and breed in community conditions as observed under captivity. Thus there is no need of special breeding tank etc. Only the females which get berried need to be

transferred to the hatching tanks, that too just two or three days prior to hatching of eggs.

Besides breeding easily in captivity, repeated broods (3–5 times) can be obtained from same females which have once bred, as observed in *rosenbergii*. Also, *malcolmsonii* collected from the riverine waters can be made to breed even in saline waters (10–12 ppt) after acclimation of both the males and females. Thus, this curyhaline adaptability in breeding has a great significance in brackishwater farming.

Though both species have almost the same life span (3-3½ years in females and more than 4 years in males), *malcolmsonii* scores over *rosenbergii* since the berried females of *malcolmsonii* have been observed at much smaller size 40 to 50 mm–while in *rosenbergii*, it is recorded as above 130 mm. However, fecundity–wise *malcolmsonii* bears relatively lesser number of eggs(minimum 3,400 and maximum about 68,000) while in *rosenbergii* minimum is 7,000 and maxlmum over 100,000.

Normal incubation period in both the species is 15–20 days (at around 27°C) but in *malcolmsonii* this period can be shortened by a week or so by adding rain water to the hatching tanks.

Considering the larval phase, both the species necessarily require saline waters for completion of metamorphosis. However, the first stage larvae of *malcolmsonii* can surrvive longer in freshwater–as long as 15 days–while those of *rosenbergii* can survive for only 5-6 days.

As in *rosenbergii*, *malcomsonii* larve accept both live and inert feeds, but the latter are observed to be hardy in withstanding starvation for as long as 15 days after hatching besides withstanding heavy turbulance (experimental obsevation). These features of the larvae may have great survival value in species like *malcolmsonii* which has established in the far interior areas.

From the point of marketability in live condition, *malcolmsonii* can withstand 14-15 hours water-free transportation (when packed in adquatic weeds) as observed both in the field and also at markets in Chandrapur and Nanded.

Polyculture with other cultivable fishes has been successfully tried in *rosenbergii*. Similar trials have been conducted with *malcolmsonii* in the departmental tanks of the Maharashtra State Fisheries

The above observations are based on the information available in published accounts of both the species and mainly on the investigations on *malcolmsonii* conducted by the authors while in the Maharashtra State Fisheries during 1968-70 and also further studies on culture and biology of the species initiated recently under the ICAR grant at the Taraporevala Marine Biological Research Station, Bombay, of the Konkan Agricultural University, in collaboration with Directorate of Fisheries, Maharashtra.

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POSSIBLE POTENTIALLY CULTIVABLE NEW SPECIES OF FRESHWATER PRAWN IN THE GENUS *MACROBRACHIUM*

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Attempts on prawn culture have so far been concentrated mainly on the Penaeid and a very few Caridean (Palaemonid) prawns. But in view of the much complicated and prolonged life history of Penaeids requiring elaborate and sophisticated farming technology, it is the Carideans with comparatively simpler life history which would require less specialised farming method. Again it is the larger Palaemonids like the giant prawn *Macrobrachium rosenbergii* etc. that have been considered although there are many more as yet unexploited Carideans which are worthwhile consideration for culture possibilities, despite their smaller size. Amongst such untapped species, particularly those with short or abbreviated life history, as in many freshwater prawns, will naturally contribute in lowering the cost of culture operations. Therefore, with a view to finding out the possible potentially culturable species, investigations were conducted on the freshwater prawns mainly from the Dharwar area including Dharwar and Belgaum districts of the Karnataka State and Wai area in the Satara District of the Maharashtra State. The families Atyidae and Palaemonidae are represented in these studies but only the Palaemonid genus *Macrobrachium* comprising the following speciese is discussd here:

1. *M. unikarnatakae* n. sp. – Impounded water from in Dharwar proper.
2. *M. sankollii* n. sp.
3. *M. tiwarii* n. sp.
4. *M. hendersodyanum* (Tiwari)

   Riverine forms in Khanapur area of Belgaum District.

   and
5. *M. kistensis* (Tiwari) – Riverine form in Wai area of Satara District.

The above species constitute a small scale fishery (described elsewhere) throughout the year in the areas covered and have their own role in the local economy.

Also, the life history studies on all these species, though conducted in details have not been included herein except for their relevant significant features in culture possibilities.

With respect to the adults of the above species, the following features merit their consideration for culture purpose:

i) *Size* : The average size range of the species is 50-80 mm which is not a negligible size.

ii) *Hardiness* : Tolerance to
(a) variety of waters (stagnant to flowing and clear to dirty) including saline waters (upto 23 ppt).
(b) low DO content of waters as experimented with primary oxidation pond waters (survival beyond 48 hrs in 50% of oxidation pond water)
c) wider range of temperature fluctuations (22 to 38° C).

iii) *Feeding habits* : Omnivorous – scavanging.

iv) *Breeding habits* : (a) Easy to Breed in captivity.
(b) Breeding almost throughout the year.
(c) Early maturation.
(d) Short interbreeding period.

v) *Fecundity* : Relatively low
Eggs : i) Size large (1.2 to 2.5 mm)
ii) Number – 100 to 250.

Besides, the following characteristics of their life history compensate for the apparent drawbacks of smaller size and relatively low fecundity of these prawns :

i) Partially or completely abbreviated development involving only 3 + 1 or 1 + 1 stages.

ii) short larval duration of less than a week.

iii) Easy feeding, not requiring costly feeds like *Artemia* nauplii

iv) Hardiness of larvae:
a) Tolerant to low DO waters.
b) Can survive and meteamorphose in saline waters even upto 20 ppt.

v) High survival percentage of larvae, postlarvae and juveniles.

In light of the above (also see Table 1), these species can now be added to the list of prospective *Macrobrachium* species for both fresh and brackish water cultures.

The above are the results of Investigations carried out during 1969 to1977.

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POSSIBLE POTENTIALLY CULTIVABLE NEW SPECIES

TABLE-I

Sr. No.	Name of species	Average size range (mm)	Fecundity (Average)	Egg size (mm)	No. of develop-mental stages (Larval +Post-larval)	Duration of Larval phase.
1.	*Macrobrachium unikarnatakae* n. sp	60-70	250	1.10 to 1.40x 1.40 to 1.90	3+1	Less than a week.
2.	*M. sankollii* n. Sp.	50-66	(Not recorded)	More than 1.0 mm	3+1	-"-
3.	*M. tiwarii* n. Sp.	70-80	100	1.0 to 1.40x 1.40 to 1.90	3+1	-"-
4.	*M. hendersodyanum* (Tiwari)	55-70	100	1.5 x 2.4	1+1	3-4 days
5.	*M. kistensis* (Tiwari)	60-70	200	1.4 x 1.8	3+1	About 7 days.

SHRIMP FARMING DEMONSTRATION BY MPEDA

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The Marine Products Export Development Authority, Cochin.

1. Scheme

MPEDA has a scheme for providing technical assistance by way of extension services, supply of inputs and provision of feasibility report. While this scheme was pending sanction, a series of preliminary demonstrations were undertaken with a view to obtaining guidelines on the economics of operation and gaining experience in organising effective input services and extension service. Seven progressive farmers, willing to make available their farms, were selected. The cost of inputs was supplied free by MPEDA. No separate staff was recruited, except for engaging fishermen on a casual basis.

2. Production and Economics

Particulars of the farm, stocking, economics etc. are given in the accompanying appendices (I-IX). It may be seen that except in one case, the demonstation was economical. The stocking was with Naran *(Penaeus indicus)* and rearing period ranged from 67 days to 137 days and the yield per hectare ranged between 214 kg., to 387 kg., with an average of 272 kg. The net profit averaged at Rs . 2,500/- per hectare after meeting an input cost of Rs. 2,280/- per hectare. The total early-fry stocked was 117, 300 and the survival was 50, 840 or 43.34%

3.0. Observations and Conclusions

These demonstrations enabled making certain useful observations and drawing some broad conclusions regarding the prospect of shrimp farming in the Cochin area.

3. 1. Stocking Material

The readily available prawn seed in Cochin area is Poovalan (*Metapenaeus dobsoni)*. Although this species was not cultured as such, they got in small quantities either through gaps in sluice shutters or due to defects in the sorting of fry. Stocking was done extensively with Naran (*Penaeus indicus)* young-ones which were available in the area. A few Kara *(Penaeus monodon)* fry, which was obtained in the collection was also released in the pond. Growth rate for a period of 100 days cultivation is roughly as under:

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* Present Address: Ministry of Agriculture, Krishi Bhawan, New Delhi.

TABLE - I

Prawn Sp.	Growth in 100 days
1. Poovalan	2.5 grams each
2. Naran	11 grams each
3. Kara	50 grams each

At the above mentioned growth and survival rate, cultivation of poovalan is not economically viable, unless natural stocking is done without clearing. Cultivation with Naran is definitely attractive with an average net income of Rs. 2,500/- per hectare. However, maximum advantage is with the stocking of Kara. Kara besides its fast growth, has a much higher unit value. The following table gives an estimation of the averageproduction per hectare with Poovalan, Naran and Kara assuming the growth as indicated in Table 1 and adopting a survival of 43%, with due adjustment in stocking rate for the various species.

TABLE - II

Name of Species	Stocking Rates	Prawn production per hectare (kg)	Estimated price per kg. head-on at site (Rs.)	value realizable (Rs.)	Input cost	Net profitability (Rs.)
Poovalan	1,00,000	107.5	7	752	2280	— 1528
Naran	70,000	272	17.6	4780	2280	+ 2500
Kara	20,000	430	60.0	25800	2250	+23550

APPENDIX - I

1.	Name of the pond owner	: Shri B. M. Edward
2.	Area of the pond	: 0.15 hectare
3.	Type of pond	: Perennial
4.	Average depth	: 1.5 m.
5.	Flow of water	: Minimum entry of tidal water through the gaps in the sluice gate.
6.	Salinity at the time of stocking	: 13‰
7.	Salinity at the time of harvest	: 33‰
8.	Date of stocking	: 27.12.1977
9.	Date of harvest	: 10.5.1978
10.	Nature of bottom	: Sandy
11.	Nature of clearing	: 3 bags of mahua oil-cake

12.	Manuring	:	No manuring
13.	Artificial feed	:	No artificial feeding
14.	Colour of water	:	light green
15.	Species of prawn seed stocked	:	Naran *(Penaeus indicus)*
16.	No. stocked	:	9,300
17.	No. recovered	:	3,050
18.	Average size at the time of stocking	:	17.5 mm.
19.	Average size at the time of harvesting	:	115 mm.
20.	Value of inputs		
	(a) Mahua oil-cake & application cost	:	Rs. 180
	(b) Seed and stocking cost	:	Rs. 80
	(c) Harvesting cost	:	Rs. 50
	(d) Cost of pumping out water	:	Rs. 100
			Rs. 410.00
21.	Total production	:	32 Kg.
22.	Value realized per kg.	:	Rs. 20.00
23.	Total value realized	:	Rs. 640.00
24.	Remarks	:	Periodical sampling was carried out. There was practically no growth after the first 90 days. This might have been due to: 1. lack of food in the absence of tidal inflow, 2. accumulation of metabolites, and 3. low fertility of pond.

APPENDIX - II

1.	Name of the pond owner	:	Shri T. M. Xavier
2.	Area of the pond	:	0.54 hectare
3.	Type of pond	:	Paddy field under cultivation
4.	Average depth	:	0.6 m.
5.	Flow of water	:	Continuous tidal flow through the screen from a nearby prawn filtration unit.
6.	Salinity at the time of stocking	:	13‰
7.	Salinity at the time of harvesting	:	N. A.
8.	Date of stocking	:	17.1.1978
9.	Date of harvesting	:	9.4.1978
10.	Nature of bottom	:	Muddy

11.	Nature of clearing	:	7 bags of mahua oil-cake applied for clearing the pond.
12.	Manuring	:	No manuring
13.	Artificial feed	:	No artifical feeding
14.	Colour of water	:	Clear with filamentous algae
15.	Species of prawn stocked	:	Naran *(Penaeus indicus)*
16.	No. stocked	:	27,500
17.	No. recovered	:	16,600
18.	Average size at the time of stocking	:	20 mm.
19.	Average size at the time of harvesting	:	100 mm.
20.	Value of inputs		
	(a) Mahua oil-cake & application fee	:	Rs. 420
	(b) Seed & stocking cost	:	Rs. 270 } Rs. 890/-
	(c) Harvesting cost	:	Rs. 200
21.	Total production	:	126 Kg.
22.	Value realized per kg.	:	Rs. 16.00
23.	Total value realized	:	Rs. 2,000/-
24.	Remarks	:	Periodical sampling was carried out. Growth rate was satisfactory. The prawn culture work had to be prematurely terminated as the owner wanted the field for paddy cultivation.

APPENDIX - III

1.	Name of the pond owner	:	Shri K. J, Herschel
2.	Area of the pond	:	0.22 hectare
3.	Type of pond	:	Paddy field, not under cultivation
4.	Average depth	:	0.7 m,
5.	Flow of water	:	Continuous through the screen. Subsequently closed when the surrounding water got polluted.
6.	Salinity at the time of stocking	:	12‰
7.	Salinity at the time of harvesting	:	29‰
8.	Date of stocking	:	24. 1. 1978
9.	Date of harvesting	:	15. 4. 1978
10.	Nature of bottom	:	Clay-sandy
11.	Nature of clearing	:	4+2 bags of mahua oil-cake applied (Please see remarks)

12.	Manuring	:	No manuring
13.	Artificial feeding	:	No artificial feeding
14.	Colour of water	:	Yellowish green
15.	Species of prawn stocked	:	Naran *(Penaeus indicus)*
16.	No. stocked	:	18,500
17.	No. recovered	:	10,000
18.	Average size at the time of stocking	:	25 mm.
19.	Average size at the time of harvesting	:	120 mm.
20.	Value of inputs		
	(a) Mahua oil-cake & application cost	:	Rs. 240 } Rs. 600/-
	(b) Seed & stocking cost	:	Rs. 185 }
	(c) Harvesting cost	:	Rs. 175 }
21.	Total production	:	86 kg.
22.	Value realized per kg.	:	Rs. 20.50
23.	Total value realized	:	Rs. 1,580/-
24.	Remarks	:	Some weed fishes, like *Ambassis* Spp. entered the farm through gaps in the sluice gate. As it was apprehended that these weed fishes would complete for food with the cultured prawn, it was decided to apply mahua oil-cake at a critical dose that would kill the weed fishes, but would not harm the prawn. Some preliminary tests were carried out to determine the critical level. The sluice gate was closed at the low tide and a concentrated solution of mahua oil-cake was sprayed on the surface. As the solution gradually sank, the weed fishes were affected and a complete kill was obtained in about 4 hours. The pond was kept under close watch and as soon as some distress sings were noticed among prawn, the sluice was opened and the water, which

24.	Remarks (Contd.....)	: was almost at high tide, rushed in diluting the concentration of the mahua oil-cake emulsion to a safe dose. In the process about 40 prawn were killed. An aerator was also kept for possible oxygenation but since there was no more distress sign, the same was not put to use. The growth rate, as revealed by periodical sampling was quite good in the first $2\frac{1}{2}$ months. There after mortality was noticed due to hydrogen sulphide pollution from reatting coconut husks in the neighbourhood and lack of oxygen due to high B. O. D. To avoid entry of polluted water, the sluice was closed to the extent practicable, and aeration carriedout using an air compressor. While this had some effect for a week, heavy mortality was noticed subsequently and the stock was harvested.

APPENDX - IV

1.	Name of the pond owner	: Shri P. J. Pailee
2.	Area of the pond	: 0.12 hectare
3.	Type of pond	: Paddy field not under cultivation
4.	Average depth	: 0.65 m.
5.	Flow of water	: Initially maintained continuous flow through a small sluice screen. During the latter part, the sluice was closed, as the incoming water was polluted.
6.	Silinity at the time of stocking	: N. A.
7.	Salinity at the time of harvesting	: N. A.
8.	Date of stocking	: 31. 1. 1978
9.	Date of harvesting	: 19. 5. 1978
10.	Nature of bottom	: Sandy

11.	Nature of clearing	:	Mahua oil-cake used
12.	Manuring	:	No manuring
13.	Artificial feed	:	No artificial feed
14.	Colour of water	:	Light green
15.	Species of prawn stocked	:	Naran (*Penaeus indicus*)
16.	No. stocked	:	10,000
17.	No. recovered	:	3,250
18.	Average size at the time of stocking	:	12.5 mm.
19.	Average size at the time of harvesting	:	100 mm.
20.	Value of inputs		
	(a) Mahua oil-cake & application cost	:	Rs. 240
	(b) Seed & stocking cost	:	Rs. 100
	(c) Harvesting cost	:	Rs. 75
			Rs. 415/-
21.	Total production	:	30 Kg.
22.	Value realized per Kg.	:	Rs. 16.50
23.	Total value realzied	:	Rs. 488/-
24.	Remarks	:	Periodical sampling was carried out. There was practically no growth after 86 days, the reason being; (1) lack of food in the pond due to closure of the sluice and sandy bottom, (2) low fertility of pond, and (3) accumulation of metabolites particularly because of the shallow depth.

APPENDIX - V

1.	Neme of the pond owner	:	Shri K. P. George
2.	Area of the pond	:	0.4 hectare
3.	Type of pond	:	pond used for prawn filtration
4.	Average depth	:	0.9 m.
5.	Flow of water	:	Continuous tidal flow through screened sluiee gate.
6.	Salinity at the time of stocking	:	20‰ approx.
7.	Salinity at the time of harvesting	:	15‰ approx.
8.	Date of stoking	:	12.2·1978
9.	Date of harvesting	:	20.5.1978
10,	Nature of bottom	:	Clay and sand

11.	Nature of clearing	:	Muha oil-cake applied
12.	Manuring	:	No manuring
13.	Artificial feed	:	No artificial feeding used
14.	Colour of water	:	Yellowish green
15.	No. stocked	:	26,000
16.	No. recovered	:	10,200
17.	Average size at the time of stocking	:	25 mm.
18.	Averege size at the time of harvesting	:	125 mm.
19.	Value of inputs		
	(a) Muha oil-cake & application cost	:	Rs. 300
	(b) Seed and stocking cost	:	Rs. 260
	(c) Harvesting cost	:	Rs. 180
			Rs. 740/-
20.	Total production	:	116 Kg.
21.	Value realized per kg.	:	Rs. 22.00
22.	Total value realized	:	Rs. 2535
23.	Remarks	:	The prawn stocked showed uniformly good growth

APPENDIX - VI

1.	Name of the pond owner	:	Shri V. K. Dey
2.	Area of pond	:	0. 1 hectare
3.	Type of pond	:	Perennial
4.	Average depth	:	0. 9 m.
5.	Flow of water	:	Slow flow through screen direct from backwater.
6.	Salinity at the time of stocking	:	N. A.
7.	Salinity at the time of harvesting	:	N. A.
8.	Date of stocking seed	:	17. 2. 1978
9.	Date of harvesting	:	6. 6. 1978
10.	Nature of bottom	:	Muddy with sand
11.	Nature of clearing	:	Mahua oil-cake used
12.	Manuring	:	No manuring
13.	Artificial feed	:	No artificial feeding
14.	Colour of water	:	Moderately green
15.	Species of prawn seed stocked	:	Naran (*Penaeus indicus*)
16.	No. stocked	:	8,500
17.	No. recovered	:	3,8000
18.	Average size at the time of stocking	:	20 mm.

19.	Average size at the time of harvesting	: 105 mm.	
20.	Value of inputs		
	(a) Mahua oil-cake & application cost	: Rs. 120	Rs. 260
	(b) Seed & Stocking cost	: Rs. 90	
	(c) Harvesting cost	: Rs. 50	
21.	Total production	: 31 Kg.	
22.	Value realized per kg.	: Rs. 13-00	
23.	Total value realiezd	: Rs. 340/-	
24.	Remarks	: Periodical sampling was carried out. Practically there was no growth after 80 days. Reason may be due to: (1) lack of food, sluice gate being very small; and (2) low natural fertility. The poor price realization was due to the fact that majority of the prawn was under moulting at the time of harvest.	

APPENDIX - VII

1.	Name of the pond owner	: Shri B· K. Aravindakshan
2.	Area of the pond	: 0. 15 hectare
3.	Type of pond	: Paddy filed
4.	Average depth	: 0,6 m.
5.	Flow of water	: Continuous through the screen
6.	Salinity at the time of stocking	: N. A.
7.	Salinity at the time of harvesting	: N. A.
8.	Date of stocking	: 20.2.1978
9.	Date of harvesting	: 29.4.1978
10.	Nature of bottom	: Clay-sandy
11.	Nature of clearing	: Mahua oil-cake used
12.	Manuring	: No manuring
13.	Artificial feed	: No artificial feed
14.	Colour of water	: Colourless with filamentous algae
15.	Species of prawn fry stocked	: Naran (*Penaeus indicus*)
16.	No. stocked	: 17,500
17.	No. recovered	: 3,940
18.	Average size at the time of stocking	: 22.5 mm.

19. Average size at the time of harvesting : 105 mm.

20. Value of inputs

(a) Mahua oil-cake & application cost : Rs. 300

(b) Seed & stocking cost : Rs. 180 } Rs. 530/-

(c) Harvesting cost : Rs. 50

21. Total production : 36 Kg.

22. Value realized per Kg. : Rs. 13.50

23. Total value realized : Rs. 455/-

24. Remarks : The water level was low and birds (crane) used to take away prawn particularly in the morning hours. Hence recovery was very poor. Individual growth was, however, good.

APPENDIX VIII

SUMMARY ON YIELD

Sl. No.	Species of prawn cultured	Farm size in ha.	Sock-ing rate No./ha.	Size range at stock-ing in mm.	Average size at harvest mm.	gm.	Period of rear-ing in days	Yield rate kg/ha
1.	*Penaeus indicus*	0.15	56.000	15-20	115	10.5	131	214.00
2.	do	0.54	50.000	15-25	100	7.5	81	233.00
3.	do	0.22	80.000	20-30	120	10.0	80	387.00
4.	do	0.12	83,000	10-15	100	8.5	134	246·00
5.	do	0.40	65,000	20-30	125	11·5	96	289.00
6.	do	0.10	65,000	15-25	115	10.0	109	303.00
7.	do	0.15	100,000	20-25	105	9.0	67	237.00
							Average	272.00

APPENDIX-IX

SUMMERY OF ECONOMICS

Sl. No.	Area (ha.)	Cost of inputs (Rs)	Revenue (Rs)	Net Profit (Rs.)	Profit per ha. (Rs.)
1.	0.15	410	640	230	1,533.33
2.	0.54	890	2,000	1,110	2,055.55
3.	0.22	600	1,580	980	4,454.55
4.	0.12	415	488	73	608.33
5.	0.40	740	2.535	1,795	4,487.50
6.	0.10	260	340	80	800.00
7.	0.15	530	455	-75	-500.00
Total	1.68	3,845	8,038	4,193	2,495.83
				Say Rs.	2,500.00

SCOPE FOR PRAWN CULTURE IN MAHARASHTRA STATE

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Abstract

Though the bulk of Maharashtra marine prawn landings consists of non-penaied species, important penaied species such as *Penaeus indicus*, *P. monodon*, *Meta penaeus monoceros*, *M. affinis* are caught in commercial quantities off Bombay and *P. merguiensis M. monoceros*, and *M. affinis off* Ratnagiri.

In spite of the presence of numerous creeks and vast swampy areas, brackishwater fish culture has not made any headway in Maharashtra, largely because i) the very high tidal amplitude necessitates construction of very strong bunds at high cost, ii) there are no extensive backwater areas and iii) very little is known about the natural availability of shrimp seed.

Recent progress in the breeding and larval rearing of several species of marine prawns achieved at the Konkan Krishi Vidyapit and at the C. I. F. E., Bombay would lead to large scale culture and breeding of the species for commercial seed production and the brackishwater fish farm being initiated at Ratnagiri and Karanja by the Konkan Krishi Vidyapit and the Department of Fisheries respectively will become the focii for development and extension of techniques of intensive culture of prawns in Maharashtra.

A NEW SYSTEM OF PRAWN CULTURE

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Abstract

Three species of Penaeid Prawns, *Penaeus indicus*, *Penaeus monodon* and *Metapenaeus monoceros* were cultured in Nylon cages fixed in the Kovalam backwater near Madras and Pulicat lake respectively. Culture experiments conducted at both the places in the years 1976 - 77 and 1977–78 provided information on growth, survival, production, food conversion etc. Nylon cages of 10x2x1 m. size were used for the culture of juvenile prawns with stocking densities of 40 to 70 per metre square and 20 to 50 per metre square at Kovalam and Pulicat respectively. Varieties of feeds and feeding rates were tried during the rearing periods, which ranged from 84 to 126 days at Kovalam and 90 to 120 days at Pulicat. In the experiments conducted at Kovalam the rate of survival ranged from 23.33% to 100%, growth increments fluctuated between 45.98 mm/3.2 gms. and 92.43 mm/12.849 gms. and yield ranged from 40 gms. to 390 gms. per metre square in about 120 days of rearing. Whereas in the experiments conducted at Pulicat the percentage of recovery ranged from 60% to 85%, growth increment ranged from 28 mm/1.2 gms. to 68 mm/7.8 gms. and maxinum yield was worked out as 168 gms./metre square in 90 days of rearing. Individual growth was better at lower stocking densities but the total yield per cage was better at the higher stocking densities.

CASE STUDIES ON THE ECONOMICS OF AN IMPROVED METHOD OF PADDY FIELD SHRIMP CULTURE IN VYPEEN ISLAND, KERALA

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INTRODUCTION

Raising of shrimps in the paddy fields (Pokkali) of Kerala locally known as "Chemmeen Kettu", "Chemmeen Vattu" or "Adappu" is a practice more akin to capture fishery than to culture. The essential aspects of this operation in vogue include the trapping of shrimps in the field with the incoming high tides after the annual paddy harvest and filtering them through the sluice gates during favourable low tides. The prevalent state of this fishery and the possibilities for improving the production in the light of eco-biological know how have been appraised by the earlier investigators (Panikkar, 1937, 1952; Menon, 1954; Gopinath, 1956; Kesteven and Job, 1957). Experimental studies on the growth of shrimps contributing to the paddy field fishery have been made by George, Mohamed and Pillai (1968). A comparative study of the species-wise yield and economics of the traditionally operated seasonal and pereannial fields of Vypeen Island has been carried out by George (1974). These authors have directly or indirectly pointed out the need for introducing more culture techniques to enhance the yield of shrimps from paddy fields. The same had been realised by the farmers at Narakkal where half a century ago, actual culture by rearing young shrimps for two to three months was practised (Menon, 1954). However, this was not viable at that time mainly due to economic reasons.

The present communication deals with an attempt to improve the traditional paddy field shrimp fishery by incorporating culture techniques such as nursery pond, supplementary feeding, and more conducive physical environment. Of the yield and economics of four case studies reported here, three were operated using improved method and one in the tradtional manner.

Materials and Method

Investigations were carried out with the close co-operation of some of the lease holders who have accepted our guidance from time to time. Data on the catch composition, day to day income expenditure and other observations were systematically maintained in a log book.

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During 1975-76 season a 6.25 ha field at Cherai (Field A) and in 1976-77 a 7.57 ha field at Narrakal (Field B) were operated using improved method. To understand the relative efficiency of improved operation, in 1977–78 a 4.93 ha field at Narakkal (Field C) was operated with improved techniques and another field adjacent to that was operated in the traditional manner. Period of operation lasted for five months, from the middle of November to the middle of April.

All the fields were naturally well connected with the backwater system and had regular tidal flow. Field A had the additional advantage of access to' Poyil, a marine lagoon.

Preparation of the field (Inproved method)

After the raising of dykes, the sluice gates were installed in a position slightly inclined towards the incoming tide. The catch basin/sluice basin was sounded to confirm the depth (3-4 m) and evenness of bottom configuration. Irregularities detected were rectified.

The primary irrigation canals radiating from the sluice basin to the periphery of the field which were silted and eroded during the paddy harvest activities were excavated to get a width of 2–3m and a depth of 1-1.5 m at the lowest low tide. Similarly secondary-tertiary canals having 1.5-1 m width and 0.75-0.5 m depth were elaborated to form a net work, so that almost every 10 m^2 of the field was traversed by a canal. Excessive accumulation of paddy stumps and noxious weeds like Salvinia, Eichornia and filamentous algae were removed. An initial fishing was carried out using cast nets and dragnets to eliminate predatory and uneconomic species including Tilapia.

Trapping operation

Almost all the high tides during day and night particularly at dusk with satisfactory gradient were used for trapping the shrimps. A petromax lamp with a red filter was used at the sluice gate while trapping at night.

Nursery pond

In the peripheral part of the field an area of approximately 0.4 ha was maintained as a nursery pond by raising mud bunds. Bamboo screens were fixed at some places where the canals traversed the pond. During filtration the contents from the codend of the filter bag net were frequently emptied into a plastic basin half filled with water. The undersized juveniles were quickly sorted out using small hand nets and transferred to the nursery pond. When the container was immersed into the nursery 95–98% of the young shrimps actively swimmed out. Among the undersized juveniles re-introduced were *F. indicus* and *P. monodon* of length range 25-75 mm and *M. dobsoni* and *M. monoceros* measuring 15-45 mm. Considering the importance of the fast growing *P. indicus* and *P. monodon* in the economy, more attention was paid in the handling and re-introduction of these species

Crushed ground nut cake at the rate of 25 kg/0.4 ha per week was used for

supplementary feeding in the nursery pond for three months (Dec--Feb.). About 3 5% of the undersized juveniles, died during the operation has also contributed to the food resource in the nursery. At the time of filtration one of the bamboo screens of the nursery pond was removed to permit passage of shrimps into the canal. Towards the close of the leasement period, in addition to the usual filtration the terminal fishing was carried out in 3-4 days, using "Pachil", cast nets, gill nets and hand fishing. Traditionally terminal fishing in paddy fields is done by "Churning" and asphyxiating all organisms, in a destructive manner.

Yield from improved operation

The total yield of shrimps, fishes and miscellaneous species obtained during various phases [lunar] of filtration and terminal fishing operations from three fields [A, B&C] has been given in tables I-III. Maximum yield of shrimps 965.04 kg/ha was at Cherai [Field A] in 1975-76 and the minimum was 784.92 kg/ha from Narakkal (Field C) in 1977-78. The average yield of shrimps comes to 864. 80 kg/ha.

As has been observed by earlier investigators the shrimp fishery was mainly contributed by four species: *Penaeus indicus*, *Penaeus monodon*, *Metapenaeus dobsoni* and *Metapenaeus monoceros*. Among these, the highest yield was that of *P. indicus* which gave 681.29, 427.83 and 403.37 kg ha from fields A, B and C with an average yield of 504.16 kg/ha. Though this species formed the main bulk of the shrimp yield, it did not figure much in the early phases of fishing. The catch rate of this species increased with the advancement of the season.

M. dobsoni forms quantitatively the next important species, the maximum yield of which (363.5 kg/ha) was obtained from field B and the minimum was 266.03 kg/ha from field A with an average of 321.41 kg/ha. This species was available in sizable quantities from the beginning of filtration. *M. monoceros* gave an average yield of 30.2 kg/ha with a maximum of 47.95 kg/ha from field B. Among the commercial species avaiiable the lowest yield was that of *P. monodon* which formed 9.3 kg/ha on an average with the highest 17.32 kg/ha from field A.

It is interesting to note that in general the high values of percentage composition of *M. dobsoni* and *M. monoceros* apparently decreases towards the close of the season. *P. indicus* dominates the percentage composition of shrimp catch during March-April. The same is true in the case of *P. monodon*.

On an average, the net yield of edible organisms from the improved operation comes to 1273.45 kg/ha. As regards the yield of fishes, the mojor contribution comes from Tilapia, Etroplus and Mullets. A drastic variation could be noticed in the total yield of fishes (from 76 kg/ha-588 kg/ha) during 1976-78. Of these Tilapia accounted for 75% of the catch in field B and C whereas in field A it was below 10%.

Miscellaneous catch was comprised of a host of species of Crustaceans and fishes. *Ambassis* sp, *Barbus* sp, *Arius*

TABLE - I

Yield of shirmp and fish (in Kg) from a 6.25 ha. paddy field (A) at Cherai operated under improved method during 1975-76

Sl. No.	Period of fishing	Catchcomposition of shrimps				Total catch of shripms	Yield of shrimps per hectare	Yield of fishes	Miscellaneous catch	Total yield	Total yield /ha
		P. indicus	*P. monodon*	*M. dobsoni*	*M. monoceros*						
1.	5.12.75-9.12.75	-	-	162.00 (100%)	-	162.00	25.92	-	-	162.0	25.92
2.	15.12.75-19.12.75	-	-	183.00 (100%)		183.00	29.28	5.5	5.0	193.5	30.96
3.	29.12.75-2.1.76	10.95 (32.4%)	0.500 (1.48%)	19.90 (58.87%)	2.45 (7.25%)	33.8	5.41	12.0	8.0	53.8	8.61
4.	14.1.76-23.1.76	283.75 (58.12%)	-	204.50 (41.88%)	-	488.25	78.12	16.5	10.0	514.75	82.36
5.	28.1.76-6.2.76	355.50 (58.76%)	7.000 (1.15%)	242.50 (40.08%)	-	605.00	96.8	27.5	25.0	657.5	105.2
6.	12.2.76-20.2.76	533.00 (64.22%)	31.000 (3.73%)	266.00 (32.05%)	-	830.00	132.8	32.5	15.0	877.5	140.4
7.	26.2.76-7.3.76	465.50 (69.84%)	26.000 (3.9%)	175.00 (26.26%)	-	666.5	106.64	65.0	2.0	733.5	117.36
8.	12.3.76-21.3.76	807.80 (86.59%	27.150 (2.91%)	98.00 (10.5%)	-	932.95	149.27	85.0	8.0	1025.95	164.15
9.	28.3.76-6.4.76	888.16 (95.54%)	4.400 (0.47%)	37.00 (3.98%)	-	929.56	148.73	75.0	7.0	1011.56	161.85
10.	Terminal fishing 8.4.76	913.5 (76.13%)	11.700 (0.97%)	274.80 (22.9%)	-	1200.0	192.00	156.0	125.0	1481.00	236.96
11.	Total catch	4258.1 (70.60%)	108.25 (1.79%)	1662.70 (27.57%)	2.45 0.04%	6031.5	965.04	475.0	205.0	6711.5	1073.84
12.	Catch/hectare	681.29	17.32	266.03	0.39	965.04	-	76.0	32.8	1073.84	

TABLE - II

Yield of shrimp and fish (in kg) from a 7.57 ha paddy field (B) at Narakkal operated under improved method during 1976-77

Sl. No.	Period of fishing	Catch composition of shrimp				Total catch of shrimp	Yield of shrimps per hectare	Yield of fishes	Miscellaneous catch	Total yield	Total yield/ha
		P. indicus	*P. monodon*	*M. dobsoni*	*M. monoceros*						
1.	3.12.76-8.12.76	-	-	126.00 (85.19%)	21.9 (14.81%)	147.9	19.54	-	-	147.9	19.54
2.	18.12.76-23.12.76	0.500 (0.16%)	-	264.60 (85.82%)	43.22 (14.02%)	308.32	40.73	-	-	308.32	40.73
3.	2.1.77-8.1.77	3.800 (0.78%)	-	382.80 (78.70%)	99.82 (20.52%)	486.442	64.26	-	-	486.42	64.26
4.	16.1.77-23.1.77	195.19 (24.37%)	0.500 (0.06%)	524.60 (65.48%)	80.80 (10.09%)	801.09	105.82	14.00	19.0	834.09	110.18
5.	1.2.77-8.2.77	310.10 (37.88%)	3.600 (0.44%)	437.20 (53.40%)	67.76 (8.28%)	818.66	108.14	30.0	27.0	875.66	115.68
6.	15.2.77-22.2.77	346.70 (47.75%)	5.400 (0.74%)	350.5 (48.27%)	23.52 (3.24%)	726.12	95.92	69.0	31.0	826.12	109.13
7.	2.3.77-9.3.77	423.80 (57.83%)	8.100 (1.11%)	286.2 (39.06%)	14.62 (2.00%)	732.72	96.79	118.0	48.0	898.72	118.72
8.	16.3.77-23.3.77	496.80 (74.59%)	11.300 (1.70%)	148.98 (22.37%)	9.00 (1.35%)	666.08	87.99	565.0	67.0	1298.08	171.48
9.	1.4.77-9.4.77	527.5 (89.68%)	4.200 (0.71%)	56.50 (9.61%)	-	588.2	77.70	1136.0	94.0	1818.2	240.19
10.	Terminal fishing	934.3 (83.64%)	6.100 (0.55%)	174.30 (15.60%)	2.30 (0.21%)	1117.0	147.56	1298.0	107.0	2522.0	333.16
11.	Total	3238.69 (50.66%)	39.200 0.61%)	2751.68 (43.05%)	362.94 (5.68%)	6392.51	844.45	3230	393.0	10015.51	1323.05
12.	Catch/hectare	427.83	5.18	363.50	47.95	844.45	-	426.68	51.92	1323.05	-

TABLE – III

Yield of shrimp and fish from a 3.93 ha paddy field (C) at Narakkal, operated under improved method during 1977-78

Sl. No.	Period of fishing	Catch composition of shrimp				Total catch of shrimps	Yield of shrimps per ha	Yield of fishes	Miscel-laneous catch	Total Yield	Total Yield/ hectare
		P. indicus	*P. mono-don*	*M. dob-soni*	*M. mono-ceros*						
1.	8.12.77 - 10.12.77	-	-	90.00 (100%)	-	90.00	18.96	-	-	90.00	18.96
2.	22.12.77-25.12.77	-	-	148.00 (100%)	-	148.00	30.02	-	-	148.00	30.02
3.	6.1.78-10.1.78	2.00 (0.57%)	-	269.50 (77.33%)	77.00 (22.09%)	348.5	70.69	-	-	348.5	70.69
4.	20.1.78-27.1.78	131.50 (25.56%)	-	332.50 (64.63%)	50.50 (9.82%)	514.5	104.36	-	-	514.5	104.36
5.	4.2.78-11.2.78	204.50 (38.66%)	0.500 (0.09%)	280.00 (52.93%)	44.00 (8.32%)	529.0	107.3	50.5	-	579.5	117.55
6.	19.2.78-26.2.78	185.70 (48.63%)	1.200 (0.31%)	187.00 (48.97%)	8.00 (2.09%)	381.9	77.46	270.0	-	651.9	132.23
7.	6.3.78-13.3.78	277.00 (65.64%)	2.990 (0.71%)	135.00 (31.99%)	7.00 (1.66%)	421.99	85.60	459.0	23.50	895.49	181.64
8.	21.3.78-29.3.78	330.25 (81.42%)	4.600 (1.13%)	66.00 (16.27%)	4.75 1.17%	405.60	82.27	512.0	37.00	954.6	193.63
9.	4.4.78-11.4.78	288.30 (90.59%)	7.700 2.42%	16.50 (5.18%)	5.75 (1.81%)	318.25	64.55	768.0	60.50	1146.75	232.61
10.	Terminal fishing	569.40 (79.97%)	5.70 (0.80%)	125.56 (17.64%)	11.34 (1,59%)	710.0	144.42	849.0	127.00	1688.00	342.39
11.	Total catch	1988.65 (51.39%)	22.6 (0.58%)	1650.06 (42.65%)	208.34 (5.38%)	3869.65	784.92	2900.0	248.00	7017.65	1423.46
12.	Catch/hectare	403.37	4.58	334.69	42.26	784.92	-	588.24	50.30	1423.46	-

sp., *Cyprinoides* sp., *Platycephalus* sp., *Gobius* sp., *Anchoviella* sp., *Therapon* sp., *Hemiramphus* sp., *Sillago* sp., *Ophiocephalus* sp., *Muraenosox* sp., etc. were occurred in small quantities. Decapods like *Scylla serrata*, *Neptunus pelagicus Acetes* sp. and a few species of uneconomic varieties of shrimps were also caught.

Yield from traditional field

Shrimp yield from the traditionally operated field comes to 637.46 kg/ha which is the lowest among four fields. As regards the species, the highest yield was that of *M. dobsoni* (293.55 kg/ha). Among all the four fields *M. monoceros* gave the highest yield 72.28 kg/ha in the traditional farm (See Table IV). In the magnitude of yield *P. indicus* ranks second with a total of 268.02 kg/ha and *P. mondon* is represented with 3.61 kg/ha.

The yield of 662.71 kg/ha obtained from this field was the highest among the fish yield from all the four. However, 90% of the fish catch was comprised of *Tilapia* which was rather uneconomic. A total yield of 1372.39 kg/ha was available from the traditional field.

Economics

A statement showing the expendeture and income of improved and traditional operation (Table V) reveals that the highest net profit, Rs 2,365.44/ha was realised from field A at Cherai in 1975–76 and the lowest profit was from field C at Narakkal Rs 718.38/ha. The amount of profit appears directly proportional to the availability of the quality shrimps like *P. indicus* and also it seems to be inversely proportional to the quantity of species other than shrimps.

Expenditure on paddy field fishery, is mainly influenced by the lease amount which is increasing year after year. It can be seen from the table that the lease amount fixed for a 6.25 ha field (A) in 1975 remains almost unchanged for a 4.93 ha field (C) in 1977. As regards expenditure the main difference between the improved and traditional method lies on items like preparation of the field and nursery operation. However, this difference did not figure much in the operational expenditure of field D (Rs 8,074.06) as the lease amount was rather high. This, together with low yield of shrimps from traditional operation resulted in a loss of Rs 1,408.75/ha. The expenditure on wages did not vary considerably during these years. As could be seen in the yield of shrimps, the level of profit in improved operation also shows a downward trend from 1975-76 to 1977-78.

Discussion

Results of the case studies show that the improved method of operation is economically more advantageous than the traditional one even though the former incurs more initial expenditure. Prawn production in paddy fields of Kerala has been estimated by several investigators in the past. Menon (1954) has arrived at an average annual rate of 1079 kg/ha and Gopinath (1956) has observed 1184 Kg/ha. Production figure of 514 kg/ha has been reported by George, Mohamed and Pillai (1968).

TABLE IV

Yield of shrimp and fish from a 3.03 ha paddy field (D) at Narakkal operated in traditional manner during 1977-78

Sl. No.	Period of Fishing	Catch composition of shrimp				Total catch of shrimps	Yield of shrimps per ha	Yield of fishes	Miscellaneous catch	Total yield	Total yield per ha
		P. indicus	*P. monodon*	*M. dobsoni*	*M. monoceros*						
1.	8.12.77-10.12.77	-	-	24.40 (100%)	-	24.40	8.05	-	-	24.40	8.05
2.	22.12.77-25.12.77	-	-	57.81 (100%)	-	57.81	19.08	-	-	57.81	19.08
3.	6.1.78-10.1.78	-	-	150.08 (70.52%)	63.00 (29.48%)	213.68	70.52	11.0	-	224.68	74.15
4.	20.1.78-27.1.78	8.60 (3.21%)	-	202.12 (75.38%)	57.40 (21.41%)	268.12	88.49	60.0	-	328.12	108.29
5.	4.2.78-11.2.78	92.60 (29.16%)	0.25 (0.08%)	180.50 (56.84%)	44.20 (13.92%)	317.55	104.80	134.0	-	451.55	149.02
6.	19.2.78-26.2.78	221.40 (64.65%)	0.75% (0.22%)	96.10 (28.06%)	24.20 (7.07%)	342.45	113.02	187.0	9.8	539.25	177.97
7.	6.3.78-13.3.78	134.30 (60.97%)	2.20 (0.99%)	69.98 (31.77%)	13.80 (6.26%)	220.28	72.70	276.0	16.6	512.88	169.27
8.	21.3.78-29.3.78	178.25 (72.16%)	3.70 (1.50%)	54.82 (22.19%)	10.30 (4.17%)	247.03	81.54	314.0	31.4	592.43	195.52
9.	4.4.78-9.4.78	83.00 (80.95%)	1.60 (1.56%)	15.43 (15.05%)	2.50 (2.44%)	102.53	33.84	486.0	43.0	631.53	208.43
10.	Terminal fishing	93.94 (54.42%)	2.45 (1.42%)	72.62 (42.07%)	3.61 (2.09%)	172.62	56.97	540.00	118.0	830.62	274.13
11.	Total catch	812.09 (42.04%)	10.95 (0.57%)	889.48 (46.05%)	219.01 (11.34%)	1931.53	637.46	2008.0	218.8	4158.33	1372.39
12.	Catch/hectare	268.02	3.61	293.55	72.28	637.46	-	662.71	72.21	1372.39	-

TABLE V

Statement showing the expenditure and income from the improved/traditional method of shrimp culture in paddy field

Sl No.	Item	Operated under improved method Field A (6.25 ha) 1975-76	Field B (7.57 ha) 1976-77	Field C (4.93 ha) 1977-78	Traditional Field D (3.03 ha) 1977-78
	EXPENDITURE				
1.	Lease amount and licence fee	19,250.00	37,250.00	19,400.00	16,150.00
2.	Sluice fabrication, installation and maintenance	1,930.00	1,750.00	1,450.00	1,000.00
3.	Preparation of field, dykes, canals, eradication of weeds and predators	1,850.00	2,275.00	1,479.00	300.00
4.	Workshed and Canoes	1,150.00	1,300.00	1,050·00	550.00
5.	Lamps, Oil, Bamboo/Plastic screen	1,420.00	1,550.00	1,320.00	780.00
6.	Nets and Plastic basins	1,100.00	1,250.00	1,025.00	650.00
7.	Nursery, operation (including feed)	750.00	810.00	900.00	-
8.	Contingencies	1,035.00	950.00	875.00	258.00
9.	Wages of workmen	10,567.00	11,250.00	7,776.00	3,650.00
10.	Interest on capital @ 14%	1,557.50	2,646.88	1,500.56	1,134.41
11.	Total expenditure	40,609.50	61,031.88	36,775.56	24,464.41
12.	Expenditure per hectare	6,497.52	8,062.34	7,459.55	8·074.06
	INCOME				
1.	Sale proceeds from shrimp	54,001.00	62,499.37	36,217.33	16,257.90
2.	-do-from fishes and other items	1,392.50	11,698.00	4,100.00	3,938.00
3.	Total income	55,393.50	74,197.37	40,317.33	20,195·90
4.	Income per hectare	8,862.96	9,801.50	8,177.93	6,665.31
5.	Total profit (+)/loss(—)	14,784.00	13,165.49	3,541.77	4,268.51(—)
6.	-do-per hectare	2,365.44(+)	1,739.16(+)	718.38(+)	1,408.75(—)

George (1974) worked out an average yield of 903.3 kg/ha with the range from 1059.6 kg/ha in 1969–70 to 754.6 kg/ha in 1971-72. In general these reports points at a regressive trend in the yield of shrimps from the traditionally operated paddy field fishery during past three decades. In the present study, an yield of 637 kg/ha obtained from the traditionally operated field in 1977-78 confirms this trend. But in the same year an yield of 784 kg/ha has been obtained from the adjacent field which is ecologically identical to the former (data unpublished). Moreover higher yields of shrimps were available from the improved operation in 1976-77 (844.45 kg/ha) and in 1975-76 (965.05 kg/ha).

It has to be admitted that the 1977–78 season was in general a failure as regards paddy field shrimp fishery and most of the lease holders had to sustain heavy losses. Probably the lingering of rain towards the post monsoon months, till December and the consequent efflux of fresh water from the estuary might have hindered the ingression of shrimp from the inshore waters to the backwater. In paddy fields, a salinity less than 10‰ was observed till the end of December in 1977 whereas in the normal course it would be 20-25‰ in December.

Further, a recession in the market value of shrimps together with an unusually high lease amounts in 1977-78 rendered the operation unprofitable to traditional operators. Against this background, a profit of Rs 718.38/ha realised from field C in 1977-78 season seems to be mainly due to the improvement in operation, particularly fattening in the nursery. Constant retrieval of undersized juveniles from the filter bag net and growing them in the nursery pond with supplementary feed have resulted in improving the rate of yield.

In the traditional operation M.*dobsoni* used to dominate the catch composition of shrimps, (George 1974) whereas in the improved operation, .*P indicus* was found to dominate (Table I-IV) This may be due to the facility provided for exploiting the potentiality for fast growth of this species by nursery technique. Thus the improved operation could enhance the production of more economically important species and at the same time facilitate the efficient utilization of the juvenile shrimp resource naturally recruited into the paddy fields.

The average net production of edible species (Crustaceans and fishes) from the improved fields comes to 1272.45 kg/ha. Compared to this, the traditional field yielded a better crop of 1372.34 kg/ha. This shows that the improved method has not basically influenced the total yield whlch is interlinked with the primary productivity of backwater environment (Qasim et al, 1969).

During the warmer months (March-April) heavy mortalities of juvenile shrimps could be noticed in the shallower regions of some of the traditional field especially when they happen to get trapped in ditches during day time. Also excessive accumulation of organic matter (paddy stumps and weeds) rapidly decompose to create local anoxic condition harmful to animals and aero–

bic bacteria (Ardiwinata, 1958). The deeper and elaborate net work of canals in the improved fields were designed to provide shelter from higher temperature and access to a more oxygenated medium.

As mentioned earlier *Tilapia* formed the main component of the fish catch in recent years. It has emerged as a major consumer population competing with all other species for the food and environment. It has been observed that they turn to be facultative predators on shrimp juveniles at times. Elimination of all fishes in the beginning of operation helped to reduce the density of their population in improved fields.

Investment in the present day paddy field shrimp fishery of Kerala involves an element of risk as the economic success depends largly on the coincidence of environmental factors conducive to the ingression of juveniles and post larval shrimps into the field. However, the improved operation incorporating culture techniques like nursery, supplementary feeding, retrieval of undersized juveniles, improved canal system, weeding and elimination of predators and uneconomic species can certainly reduce the risk by enhancing the production of desirable species like *P. indicus* and *P. monodon*. Further improvement in the economy of the system could be achieved if dependable source of juvenile shrimps could be opened by developing hatchery and rearing techniques. The basic incentive for the expansion in this field warrants a stable and reasonable market value for shrimps. However, the problem of regressive trend observed in the past three decades in this fishery remains unanswered. Probably the study of intensity of exploitation of natural stock and the environmental deterioration might answer this meaningfully.

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A PROPOSED PROJECT ON BRACKISHWATER FISH FARM AT JODIA, GUJARAT

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Abstract

Gujarat has a coastline of 1663 kms, facing the Arabian sea, from Lakhpat in the north to Umbergaon in the south, with two gulfs viz., Gulf of Kutch and Gulf of Cambay. It has large numbers of creeks, rivers, rivulets, low lying marshes and mangroves swamps. Adjoining to these are about 3,76,000 hactares of Kharland/brackish water area. This vast brackishwater area can easily be utilized for brackish water culture and or mari-culture.

Considering the immense potential of these natural conditions and other local factors, the Department of Fisheries, Govt. of Gujarat has undertaken a centrally sponsored brackishwater scheme at Jodia in Saurashtra.

The selected project site is located near new port and is approximately 4 kms from Jodia village in the northern direction. It is proposed to take up essential sea water into the farm through the creek that connects the new port area with Gulf of Kutch. The physico-chemical properties of water is highly suitable for brackishwater shrimp/fish culture. Fry and fingerlings of mullets, Indian shad and other culturable species are available in the nearby fishing centres. Mature prawns, their eggs and larvae are found in huge quantities at Surajbari, a nearby prawn landing centre. The farm is proposed to have 11 nursery ponds of 0.24 ha each and 12 rearing ponds of 0.90 to 2.4 ha. A settling tank of 1.4 ha is also provided as silt trap.

POTENTIALS OF BRACKISHWATER PRAWN CULTURE IN INDIA

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Introduction

Considerable interest has been shown in the last decade for the development of prawn culture in India, mainly due to the continued high demand for good quality prawns for export. The inability of the capture fisheries to cater the needs of export industry and internal demand also has provided some impetus. Inspite of India's long tradition in the field of culture the prawn culture technique remained expirical and at a very low subsistance level till recently. The age old practice of 'Bhasabada' system of fishery in W. Bengal and 'trapping-cum-holding' of prawns in the paddy fields of Kerala is progressively adopting scientific methods of aquaculture in brackishwaters. The cultivable brackishwater area in India is estimated to be about 2.02 million ha (Jhingran and Gopalakrishnan, 1972) with 1.43 million ha under brackishwater swamps (George, 1974). Encouraging results have been obtained in the selective culture of different species of prawns (Verghese *et al.*, 1975; Jhingran, 1977). In this paper an attempt is made to examine the existing prawn culture systems in India and the possibilities of adopting improved scientific farm management techniques to improve the quality and quantity of yield.

Traditional culture Practices

In the Sunderbans of W. Bengal prawn culture is known to exist from 1829–30 (Subrahmanyam, 1972). The culture fields known as 'Bheries' are large impoundments of 50 to 200.ha in the intertidal zone of Hooghly-Matlah estuary. The tidal amplitude in this area ranges detween 1.8 m and 4·6 m. During high tides, generally from March onwards, water containing prawn and fish seed is drawn into the impoundments. This operation is continued till September. The seed entered into this impoundments are allowed to grow for few months and the capture operations starts from July, with the break of monsoon. The prawn species thus trapped are mainly, *Penaeus monodon, P. indicus, Metapenaeus monoceros, M. brevicornis, Macrobrachium rosenbergii, M. rude and Palaemon styliferus* (Pakrasi *et al.*, 1964). Several species of fishes also enter into the impoundments and grow, The total estimated area under this type of bheri culture is about 9000 ha and the yield of prawn ranges between 158–672 kg/ha.

In Kerala the paddy fields adjoining the tidal brackish-waters are also used as prawn trapping-cum-holding areas for

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short durations. The tidal amplitude in this region is below 1 m. As in the bheries the prawn and fish seed are let in along with flood-tide water. The operation commences during September-October. The more prevalent species of prawn encountered are *P. indicus*, *Metapenaeus dobsoni*, *M. affinis* and *M. monoceros*. The prawns are removed periodically, commencing from December. Largest catches are generally made in April when the fields are drained completely. About 4500 ha are under this paddy-cum-prawn culture. The yield of prawns varies from field to field depending upon the tidal influence, and ranges from 900 kg to 2700 kg/ha(Kurian and Sebastian, 1976). Experimental studies conducted in the paddy fields have shown that culturing juvenile prawns for about a month results in large-sized prawns than those obtained from the traditional operation for longer period (George *et al.*, 1968).

The disadvantages of this extensive culture system lies in the poor quality of yield; the production mainly consist of smaller varities of prawns. Enormous quantities of prawn seed are entering into the impoundment but their chances of survival and growth are very poor due to competition for food and space. Predation by carnivorous and predatory fishes also takes a heavy toll In the absence of proper management large scale wastage of land and seed are known to occur. Recent research investigations have shown that through intensive culture of selected species in much lesser area of land the production can be increased substantially.

Selective Culture of Prawns

Out of about 75-80 commercially important prawn species recorded only 7 or 8 are found suitable for culturing in brackishwater (Gopalakrishnan, 1973; Mohamed, 1973) The important criteria for selection are:

1) Ability to grow rapidly in brackishwater ponds with higher survival rate.

2) Hardiness to the species for handling and its tolerance to fluctuations in salinity, temperature and other physico-chemical factors prevalent in brackishwater farms.

3) Availability of seed.

4) Adjustability to farm management measures such as high stocking, ability to consume artificial feed with satisfactory conversion and easy recovery from ponds.

Bionomics of few selected species of prawns presently under cultivation in different parts of the country are presented in Table 1.

Seed Resources of Cultivable Prawns

Seed of the cultivable species are collected from tidal estuaries, coastal lagoons and lakes by different types of gear. Seasonal abundance and availability of the seed in the Hooghly-Matlah estuaries, Chilka lake and Pulicat lake are thoroughly investigated under the brackishwater prawn and fish seed prospecting survey seheme of the Central Inland Fisheries Research institute,

TABLE I

Bionomics of some important brackishwater prawns cultivated in India.

Species	Food and feeding habits	Growth	Maturity and breeding	Distribution within Indian water
1	2	3	4	5
1. *Penaeus indicus*	Omnivorous feeder, food items mainly detritus, small crustaceans, polychaets etc.	Maximum recorded size 230 mm. attains marketable size of 80-120 mm in 90–100 days under cultural conditions.	Do not attain maturity in culture condition; breeds in the deeper waters of the seas. Postlarvae migrate to estuaries. Controlled breeding has been successfully conducted.	Available both in the east & west coast. More abundant in the coastal zones of Karnataka, Kerala, Tamil-Nadu, A. P., Orissa and W. Bengal.
2. *P. monodon*	Omnivorous with preference for animal matter like polychaets crustaceans, insects, small molluses etc.	Maximum recorded size 320 mm. Rate of growth 17.55-55.20 mm/month; under short term crops, 40–50 mm juveniles attain 130–140 mm size in 2 months in well prepared ponds. Grows to about 180-250 mm in one year.	Do not attain maturity in ponds. Breeds in the sea near to estuarine mouths and postlarvae of 10–20 mm size migrate to the estuaries, lakes and backwaters. Induction of maturity and breeding under controlled conditions has been achieved.	Represented in the East & West coast, form large scale fishery in the bheries of W. Bengal, Chilka lake in Orissa and coastal Andhra Pradesh.

1	2	3	4	5
3. *Penaeus semisulcatus*	Generally carnivorous feeding on polychaets, crustaceans, small fishes and vegetable matter.	Maximum recorded size 250 mm. Not extensively cultivated.	Attain maturity and breed in the sea. The postlarvae migrate to estuaries, lakes and backwaters.	Forms a small fishery in the east coast of Tamil Nadu and Andhra Pradesh and also in the bheri fisheries of W Bengal.
4. *Metapenaeus dobsoni*	Feeds on foraminifers, amphipods, cladocera and diatoms.	Maximum recorded size 125 mm. In the paddy fields of Kerala grows to 61-63 mm in about 4 to 5 months.	Attains maturity & breeds in the sea. Postlarvae of 4-5 mm size migrate to the estuaries.	Good fishery in the West coasts of S. Maharastra Karnataka, Kerala and Tamil Nadu. In the east coast upto S. Orissa.
5. *M. monoceros*	Feeds on different types of animal and Vegitable matter.	Maximum recorded size 180 mm. Grows well in brackishwater ponds. Attain 100-130 mm in about 6 months.	Maturation and breeding in sea. Males attain maturity in ponds and stray females of advanced maturity stages are encountered under cultura conditions.	Available in the coasts and estuaries of Kerala Tamil Nadu, Andhra Pradesh, Orissa and West Bengal.
6. *M. affinis*	Omnivorous with preference for vegetable matter.	Maximum recorded size 180 mm. A monthly growth rate of 8.5 mm recorded from estuarine environments.	Maturation and breeding in the inshore areas.	Forms good fishery in the coasts of Gujarat, Maharastra, Karnataka and Kerala.

1	2	3	4	5
7. *M. brevicornis*	Omnivorous, feeding on detritus, animal and vegitable matter.	Maximum recorded size 125 mm. Grows to 80-100 mm in 6 months under culture conditions.	Mature and breed in the sea. Males attain functional maturity in brackishwater ponds and impregnates immature females. Females with advanced maturity are not uncommon in the ponds.	Available in the northern zones of east coast. West Bengal, coastal Andhra Pradesh and Orissa. Forms a dominant fishery in the estuaries of West Bengal,

Barrackpore (Gopalakrishnan, 1968; Gopalakrishnan and Rao, 1968; Subrahmanyam and Rao, 1970; Bhanot, 1971; Gopalakrishnan *et al.*, 1975; Chakraborty *et al.*, 1977). It is interesting to note that the postlarvae of much sought after tiger prawn, *Penaeus monodon* are available in the estuaries of lower Sunderbans in great abundance. The regular survey coducted at Kakdwip shows that as much as 20000 to 25000 larvae can be collected and segregated by a single shooting net in just one hour from the Muriganga estuary during spring tide periods of April-May (Verghese *et al.*, Ms.), Postlarvae of *P. monodon* are available throughout the year. Table II furnishes the collection data for different months for the years 1976-'77. The available information indicates that there is no dearth of prawn seed in India. However, in the long run it may not be possible to depend too much on natural sources alone for the seed.

Many countries have forged ahead in breeding prawns under controlled conditions (Shigueno 1972; Liao and Huang, 1972) and have commercialised the production of seed for culture purposes. In India, the controlled spawning and rearing of larvae are still in experimental stage (Raje and Renade 1972a 1972b; Thomas *et al;* 1974a, 1974b; Muthu *et al.*, 1974). The recently developed eyestalk ablation technique of inducing pond cultured prawns to maturity and the successful controlled breeding (Alikunhi *et al.*, 1975; Arnstein and Beard 1975; Santiago and Wear, 1976) is another promising field of research. Halder (1978) has reported induced matur-

TABLE - II

Collection of *Penaeus monodon* postlarvae from Muriganga estuary at Kakdwip during 1976-1977.

Month	Average catch/man hour *	
	1976	1977
January	26.5	1.2
February	104.5	16.9
March	114.5	75.3
April	762.2	1406.8
May	874.6	1344.1
June	468.0	906.0
July	775.5	564.4
August	294.0	216.8
September	119.5	134.0
October	116.0	91.2
November	34.7	54.1
December	190.0	28.9

* One fry collection shooting net is operated by 3 persons for 3 hour per tide.

ated is sufficient to maintain growth ation and breeding of *Penaeus monodon* reared in brackishwater ponds at Bakkhali, West Bengal. The initial success of controlled breeding is expected to lead towards commercial production through hatcheries.

Prawn Culture Technique

In the selective culture of prawns special care is needed at every step starting from the seed collection. The methods currently adopted at the Kakdwip farm of Central Inland Fisheries Research Institute for the culture of *P. monodon*, is outlined in Barrackpore (1977). The postlarvae and early juveniles are to be acclimated to culture conditions and reared in specially prepared nursery ponds till they attain size of 40-50 mm. Under controlled conditions of plastic pools with artificial feeding, postlarvae of *P. monodon* reared at a density of 4000/m³ for 15 days attained size of 17-20 mm length with a survival of 80%. With initial stocking density of 10,000/m³, thinned twice to half at fortnightly intervals, a survival of 75%, in a total period of 60 days of rearing has been obtained with final size of 45-50 mm. In the nursery pond the time taken by postlarvae to attain stockable size is much less. Table III gives the growth observed in *P. monodon* in different months in 0.02 ha nursery ponds.

In the case of another fast growing prawn *P. indicus* the postlarvae attained an average size of 40.1 mm in 30 days with 33.3% survival at stocking denisty of 0.4 million/ha (Jhingran, 1977). It is observed that in a well prepared pond the natural food gener-

TABLE - III

Growth of *Penaeus monodon* in the nursery pond during different months.

Period of rearing/ Stocking rate (No/ha)	Days after stocking (average length in mm)				
	Initial	7	14	21	28
1.11.77 to 9.12.77					
25,000/ha	16.5	21.3	41.0	55.3	66.4
50,000/ha	14.0	19.0	29.9	38.8	42.3
12.4.78 to 10.5.78					
50,000/ha	14.0	28.4	39.0	56.1	58.7
1,00,000/ha	14.0	16.1	26.5	39.3	40.9
1,50,000/ha	14.0	19.5	32.8	47.5	58.4

and in the initial nursery rearing use of artificial feeding is not practiced.

Verghese *et al*., (1975) has reported a production of *P. monodon* under monoculture at the rate of 543.30 kg/ha/6 months. The improved pond management practices has resulted in better productions in short growing periods With 3 short term crops per year total production of 1054.8 to 1185.0 kg/ha is obtained in the regular culture operations at Kakdwip. The weight of prawns harvested ranged from 15 to 35 g. In 63 days the prawns could be grown to 135.0 mm/24.4 g. from average stocking size of 52.1 mm/0.75 g. with specially compounded artificial feed based on slaughter house offal (Verghese and Singh, Ms) containing 45% animal protein, The production estimated was 343.5 kg/ha/63 days.

Production of *P. indicus* at the rate of 380 to 500 kg/ha in 90 days is reported from Madras (Jhingran, 1977). Mixed culture of prawns, *P. indicus*, *P. monodon*, *M. brevicornis*, *M. monoceros* and *Palaemon styliferus* has also given high production at Kakdwip. A total production of 623.5 kg/ha was obtained during a period of 150 days through 2 crops of 75 days duration at a stocking density of 0·2 million of seed per ha.

It is possible to improve the growth rate of prawns through further research and resorting to supplementary feeding as per the nutritional requirement of the species reared.

Economics of prawn culture

Cost of production and projected unit economics of experimental culture operations are presented in Table IV. It is seen that a high return is feasible through prawn culture at the prevailing market demand and price. Compared to carp culture in freshwater ponds the material inputs are very nominal for prawn culture. The cost of land is considerably cheap in the coastal zones where the waste land, suitable for prawn farms, is available at Rs. 3000-5000 per ha (in W. Bengal). The capital investment on construction of farm with sluice gate etc., will necessarily be heavy in the intertidal zone. A 10 ha farm is estimated to cost Rs.3,00,000 to 5,00,000. With a net return at the minimum rate of Rs. 30,000/ha/yr the capital investment can be recovered within a period of 5 years.

Future prospect and potential

India is endowed with vast resources in terms of cultivable brackishwater area of which only a small fraction is currently under traditional culture. operations, about 18,500 ha in W. Bengal and Kerala, out of 0·6 million ha of land available for development in these two states. Statewise distribution of coastal swamps suitable for prawn culture is furnished in Table V. If only 20,000 ha of these area are brought under scientific prawn culture India's total production of prawn through aquaculture can be brought to about five times from the present level of 4000 tons per year estimated by Pillay (1976). The estimated production of shrimps and prawns through aquaculture in 1975 for different countries presented in Table VI (taken from Pillay 1976) places India at the top with

TABLE IV

Costs of production and projected unit economics on per hectare basis of brackishwater prawn culture (on variable costs only.) (Adapted from Jhingran, 1977).

EXPENDITURE	Rate (Rs)	MONOCULTURE			
		P. monodom at Kakdwip		*P. Indicus* at Madras	
		Application rate/ha	Cost Rs.	Application rate/ha	Cost Rs.
1	2	3	4	5	6
1. VARIABLE COSTS					
A. ITEMS PER CROP					
a. *Material inputs*					
Urea	2/kg	100 kg	200	75	150
Superphosphate	2/kg	100 kg	200	25	50
Raw cattle dung	35/t	1000 kg	35	..	..
Feed	1/kg	-	–	–	–
Sub-total			435		200
b. Labour inputs					
Seed collection	6/p.d	15 man-days	90	15 man-days	90
Fishing	6/p.d	10 "	60	10	60
Sub-total			150		150
B. ITEMS FOR WHOLE YEAR					
a. *No. of crops/yr*			3		3
b. *Material inputs for crops/yr*			1305		600
c. *Depreciation long-life material inputs* (nets, seed carriers, buckets, petromaxes etc)			1000		1000
Material inputs-total			2305		1600
d. *Labour inputs for all crops/yr*			450		450
e. *Wage of 2 farm-hands*	250/month		6000		6000
Labour inputs-total			6450		6450
Total			8755		8050
10% contingencies			875		805
TOTAL COST OF PRODUCTION (on variable costs)			9630		8855

1	2	3	4	5	6
II.	PRODUCTION (Kg/ha)				
	1 st crop		201/100 days		302/120 days
	2 nd crop		472/120 ,,		- do* -
	3 rd crop		372/100 ,,		- do -
TOTAL	(Kg/ha/yr)		1055		906
III.	COST OF PRODUCTION (Rs./Kg)		9.13		9.77
IV.	INCOME				
	Prevailing market price (Rs./Kg)		40		36
	TOTAL INCOME (Rs.)		42200		32616
GROSS PROFIT (Rs/ha)			32570		23761

Notes : 1. Capital costs (on land and farm construction) not included. 2. Two farm hands/ha have been found sufficient in farm. If skilled farmers take up, the amount may represent the inputed cost on their wages under self employment. 3. The material imputs and yields obtained are from actual experiments. 4. The labour man-days, shown for fishing and seed collection, are based on experience of man power required and also on seed collection rates per man-hour in different areas.

* : Projected yield expected in subsequent crops.

TABLE V

Statewise availability of coastal/estuarine saline swamps and area to be brought under prawn farming.

State	Extent of swamps in million ha	Area to be developed for prawn farming in 1000 ha
East coast		
West Bengal	0.400	8.00
Orissa	0.008	0.20
Andhra Pradesh	0.200	4.00
Tamil Nadu	0.080	0.80
West coast		
Gujarat	0.376	1.50
Maharashtra	0.080	0.80
Karnataka	0.080	0.80
Kerala	0.200	4.00
Total	1.424	20.10

annual production of 4000 tons, followed by Indonesia with same production figure. However, Mohamed (1973) has stated that the annual catch of prawns from the paddy fields of Kerala alone amounts to approximately 4000 tons. The latest export data of prawn through Calcutta indicate a production of around 3000 tons from the bheries of west Bengal. In the absence of exact production figures the available information can be taken as an index of production of prawns through culture. In the draft ten year plan of aquaculture development, it is prsposed to bring about 0.45 million ha of brackishwater area under farming to produce 0.22 million tons of fish and prawn by the year 1984 (George and Sinha, 1975).

With continued and determined effort it would not be difficult to bring about 20,000 ha under prawn farming as indicated in Table V. Each maritime State of both east and west coast has got a fare share of cultivable brackishwater areas and with active interest of State Governments 1 to 2% of the land available can easily be converted into prawn farms. Projected requirement of seed of different species of prawns for the area to be developed is estimated in Table VII. Massive effort will have to be mobilised to achieve the target, but it is worth trying.

Conclusion

Selective stocking and culture of prawns in brackishwater is still in its infancy. Several infrastructure facilities are to be developed before translating the expectations into reality. The seed resources of different Maritime States are only a guess. Detailed seed prospecting survey is urgently needed: The controlled breeding of prawns that has shown promising results should be taken up seriously and hatchery production of prawn seed is to be commercialised. The brakishwater areas are under the possession of various governmental and private agencies and are not easily available to the promising entrepreneurs. Many big industrial houses have shown interest in developing brackishwater farms. Suitable legislations are needed to make the land available for quick development. The heavy financial investment at the initial stages will have to be procured. Intensive research and man power training are also to be undertaken to support the growing industry. Once it is established the prawn culture industry will revolutionize the rural economy of the coastal zones which is one of the ill developed areas at present. The major prawns can be ear-marked for earning foreign exchange while the minor varieties can meet the protien need of local population.

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TABLE VI

Estimated production of shrimp and prawns through aquaculture in 1975.

Country	Production in tons
India	4000
Indonesia	4000
Thailand	3300
Japan	2779
Ecudor	900
Taiwan	549
Singapore	105
Korea, Republic of	30
Total	15663

TABLE VII

Requirement of prawn seed for developing 20,000 ha prawn farm and expected production.

Species	Stocking density per crop No/ha	Culture area to be developed in ha	Seed requirment for 2 crops/yr in millions	Expected production in tons
Penaeus monodon	30,000	5,000	300	3500@350 kg/ha/crop.
P. indicus	70,000	5,000	700	5000@500 kg/ha/crop.
Penaeus spp and *Metapenaeus* spp under mixed culture	1,00,000	10,000	2000	12000@600kg/ha/crop.
	Total	20,000	3000	20500

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PRELIMINARY EXPERIMENTS ON TIGER PRAWN CULTURE AND A REPORT ON SEED PROSPECTING OF PENAEID PRAWNS IN KERALA BACKWATERS

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Introduction

The Kerala Agricultural University was called upon by the government of Kerala to report on the feasibility of starting commercial prawn farming in Kerala by bringing tiger prawn seed from west Bengal. Preliminary culture experiments were started in December '77 at Vyttila Fish Farm. In view of the very encouraging results of culture experiments, a special attempt on prawn seed prospecting was conducted in Cochin backwaters which resulted in the finding of Tiger prawn seed resources in commercially exploitable quantities. The results of the culture experiments and seed resources survey conducted by Kerala Agricultural University are reported here.

Material and Method:

The first consignments of 8000 post-larvae of *P. monodon* bought from Port Canning area on 29. 12. 1977 were transported by Jeep to Howrah,oxygen-packed and brought by plane the next day to Madras and on the third day morming to cochin, were stocked in a 0.17 ha pond in the Vyttila Fish Farm. The pond was prepared by eliminating all predatory fishes and manuring at the rate of 200 kg of Rock phosphate and 100 kg of Urea/ha. An average depth of 80 cm of water was retained in the pond. The water was occasionally exchanged with fresh tidal water through inlets guarded by velon net screen. As there was heavy mortality during transport the pond was stocked only at the rate of 7000/ha. Small twigs of Cassuarina planted in the pond gave necessary substratum and shelter to the prawns. The prawns were reared for 130 days during which period they were sampled periodically. 10 to 20 specimens were collected for regular length and weight measurements at each samples. The water samples were also analysed while sampling prawns. No supplementary feed was given. Final sampling was done after dewatering the pond completely.

Observations

The experiments on monoculture of *P. monodon* conducted at the Vyttila Fish Farm have shown that the specimens have grown from an average of 1.3 cm and 0.015 g. to an average of 17.95 cm and 38.64 g in a period of 130 days. There was 31% survival. The details of rate of growth are furnished in Table-I

TABLE-I

Rate of growth of *P. monodon* cultured in pond at Vyttila

Date of stocking/ sampling.	No. of days of growth after stocking	Length (Average) cm	Weight (Average) g	Salinity p. p. t.	pH	Water temperature °C
31.12.1977	--	1.3	0.015	5.26	7	32.0
30. 1.1978	30	10.0	6.45	8.75	7	34.0
9. 2.1978	40	11.8	10.56	10.32	8	32.2
6. 3.1978	65	14.8	23.00	15.20	8	32.1
31. 3.1978	90	15.9	28.75	20.05	8	32.2
10. 5.1978	130	17.95	38.64	6.24	7	32.0

Discussion

The culture of the jumbo tiger prawn, *Penaeus monodon* Fabricius has received great attention in recent years in the Philippines (Villadolid and Villaluz, 1950; Delmendo and Rabanal, 1956; Borja and Rasalan, 1968), in Taiwan (Kubo, 1956; Liao and Huang, 1970; Chen, 1972), in Indonesia (Alikunhi et. al., 1973) and in India (Subrahmanyam, 1973: Ghosh et al., 1973; Verghese et al., 1975). One of the reasons for advocating its large-scale farming is its rapid rate of growth.

P. monodon is reported to attain a length of 250 mm in one year in the culture ponds of Philippines (Villadolid and Villaluz, 1950). The species might be having a somewhat similar rate of growth in Kerala backwaters also since George and Sebastian (1970) have reported the species to grow to 210mm in the Narakkal fish Farm. It has also been observed that the prawns in the ponds die out with the onset of the first heavy monsoon rains, indicating that about one year old prawns are met with in the ponds during the summer months. Subrahmanyam [1973] who studied growth in *P. monodon* cultured in aquaria and cement cisterns with artificial feed, reported an average growth rate of 15.5 mm/month. The experiments reported by other authors also show only a similar rate of growth for this species. Delmendo and Rabanal (1956) observed an average growth of 17.19 mm/month; Kubo [1956] reported 16.5 mm/month for postlarvae and 13.8 mm/month for juveniles; Poernomo (1968) recorded growth of 17.35 mm/month and Verghese et al., (1975) reported an average monthly growth of 17.55 mm in length and 4.36 g in weight. Compared to these records, the results of the present culture experiments are remarkable in that without artificial feeding an average monthly growth of 38.42 mm in length and 8.913 g in weight could be obtained. This is more than twice the monthly rate of growth reported for this species

by the above authors. However, the above figures of rate of growth per month are not strictly comparable since different workers have stocked the prawns at different densities, stages of growth and have reared them for different duratiom.

Alikunhi et al. (1975) recorded a growth of 1.5 mm to 2 mm/day for eye stalk ablated specimens of *P. monodon* of size 100–110 mm. In the early phase of the present experiment similar rate of growth is observed. In the present culture experiments, during the first 30 days the postlarvae grew from 13 mm to 100mm registering an average growth of 2.9mml day, even though the average for 1.30 days was only 1.28 mm/day.

Tiger Prawn Seed Resources

The encouraging results of the culture experiments at Vyttila and the reported availability of tiger prawn in the Narakkal Fish Farm by natural stocking (George and Sebastian, 1970) have prompted the University to undertake a preliminary survey of the tiger prawn seed resources in the Cochin backwaters. Collections were made in the month of April 1978 from places such as Vyttila, Munambam, Malipuram and Puduveypu, of which the last place was found to be very promising. Thereafter, regular collections were made from Puduveypu area. The Midnapore type fry collection nets, locally fabricated with synthetic mosquito netting were used for the seed prospecting. The nets were operated in a side-channel of the main canal running northwards parallel to the coast in puduveypu in the Vypeen island. Collections were made during the high tides of the spring tide phases of the full moon and the new moon. A minimum of 60 cm of tidal amplitude was found to be necessary for the successful operation of these nets. Collections were washed down from the cod ends of the nets every 10 minutes and kept in plastic buckets. Small samples were taken in enamel trays and *P. monodon* post-larvae were sorted out with the help of fine brushes. The crimson strips of pigments running all along the ventral side enabled the easy recognition of the tiger prawn postlarvae. The peak availability of the seed is restricted to only 2 to 3 hours at the mid-tide stage when there is high velocity for the tidal current. From 300 to more than 1200 *P. monodon* post-larvae were collected per net per tide alongwith 3000 to 4000 juveniles of *P. indicus* and thousands of postlarvae of *P. indicus* and other species of prawns. The collections made during low tide were found to be very low in *P. monodon* seed. The availability of the seed of *P. monodon* in commercially exploitable quantities has never been reported before from Kerala backwaters. Difficulties in the procurement and transportation of tiger prawn seed from West Bengal and the high cost involved were felt as severe constraints to the development of tiger prawn farming in Kerala. It is in this context that the present finding of the tiger prawn seed resources in the Cochin backwaters has become all the more significant.

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STATUS OF PRAWN CULTURE IN INDIA AND STRATEGY FOR ITS FUTURE DEVELOPMENT

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Introduction

The world fishery production through aquaculture is estimated to be about 5 or 6 million tonnes which represent 8–10% of total world fishery production. Amongst a variety of organisms cultured at present, crustaceans form an important group. Although reliable data on the production of crustaceans from aquaculture are not available, it is estimated that the present yield from this source would easily be above 50,000 tonnes.

Among the crustaceans, prawn constitute the only group that is commercially cultured at present. The major countries that are now engaged in prawn culture on a commercial scale are India, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Thailand, Taiwan, Vietnam and United States of America.

Prawn culture in our country as well as in some of the southeast Asian countries has a long recorded history and is being traditionally practised in relatively extensive areas. Bnt in countries such as Japan, Korea, Taiwan and U. S. A. it is of recent origin, nevertheless practied inlensively on modern lines.

The importance of prawn culture was realised only a decade back when prawn production through capture fisheries and supply, could not sustain the demand. Other potentials of prawn culture in utilising the derilict waters for better aquatic harvest, in providing productive and remunerative employment, in improving the income of small farmers and in the overall development of the rural sector soon unfolded. The recognition of these opportunities and of the simple way it offers for increasing production gave an impetus for several countries to assign high priority for the development of this field in recent years.

Status of prawn culture in India.

Fisheries, like several other agriculture sectors, was a negleted field prior to Independence. Planned programmes for the development of fisheries were soon taken up in the National Plans initiated since 1951. But these programmes, by and large, underlined the capture fisheries in the marine fisheries sector obviously due to its long standing as a traditional occupation being practised by the fishermen and its resources status. These programmes helped to elevate the marine capture fisheries to a considerable extent and also in the establishment of an industry based on it. In our capture fishery,

prawns occupy an important place and the industry heavily leans on them as they constitute the major and the most valued commodity of the marine products exported from the country. However, as the exploitation for prawns in our inshore waters is stepped up, their catch is dwindling, but at the same time there is an ever increasing demand. This situation necessitated an immediate search for new resources from the hitherto unexploited areas or from the generation of new resources through aquaculture It is in this context a national awareness for the culture of prawns was felt in the latter half of the Fifth Five Year Plan.

Research efforts:

The research efforts leading to prawn culture were started in our country by early 1950's and most of these investigations were concerned with the biology of the species and isolated studies on larval development and distribution. Subsequently, comperhensive research programmes were taken up, particularly by the Central Marine Fisheries Research Institute, and the Central Inland Fisheries Research institute, both on basic and applied sides. These programmes were further strengthened and intensified during the last couple of years. In the mean while, several other Institutions such as the Konkan Krishi Vidhya Peeth, the Central Institute of Fisheries Education and the Universities like, Cochin, Kerala Madras, Annamalai and Andhra Pradesh and the Department of Fisheries in the States particularly Tamil Nadu, also initiated research programmes in this field.

As a result of the investigations conducted so far, significant break-through in the culture of commercially important penaeid and palaemonid prawns has been achieved by successful spawing, rearing and field culturing. Indigenous techniques of breeding and rearing of larvae to stocking size under controlled conditions have been developed. Concurrently, research for finding suitable feed for the larvae in different stages of development was taken up Techniques of mass culture of phytoplankters for the early larval stages, brine shrimp and zooplankters for the postlarval stages and artificial feed for juveniles are being developed. Investigations on large scale production of seed on hatchery lines are progressing in the prawn culture laboratory of the Central Marine Fisheries Reserach Institute, at Narakkal A comprehensive survey on fish seed resources including those of prawns is being undertaken with a view to locate, map and chart the seed grounds.

The traditional practice of prawn filtration as carried out in Kerala was evaluated and its disadvantages were identified for the immediate development of prawn culture. It is now suggested to streamline the practice by selective stocking of faster growing species such as *Penaeus indicus* and *P. monodon*. It is also suggested that polyculture of prawn with compatible species of fishes such as chanos, mullets and pearlspot, regular monitoring of the stocked prawns and culturing them for a specific period allowing them to grow to the marketable size for obtaining enhanced production as well as profit be undertaken. In order to

propagate this improved method of culture, demonstration projects are being undertaken in the farmers' fields. It is also shown that the prawns could be cultured not only in the brackishwaters, but also in the fallow areas such as the shallow canals in the coconut groves and salt pan reservoirs.

Developmental efforts.

Culture of prawns, *sensu stricto*, is not practised anywhere in India. In Kerala and West Bengal, a traditional practice of trapping the seed prawns and fishes brought in by the high tide currents in the lowlying fields adjacent to the backwaters and holding them in the fields for a short period before harvesting is followed since ancient times. In Kerala, this practice is undertaken in two types of fields, namely, the seasonal paddy fields and the perennial fields. In the seasonal fields a variety of paddy locally known as "Pokkali" which tolerates certain limits of the salinity of the waters, is cultivated during June to September, and in other months these fields are used for prawn filtration, which is locally known as "Chemmeen Kettu". In West Bengal, the brackishwater fields are called "Bheris". The extent of the fields currently under brackishwater prawn/fish culture is 5117 ha in Kerala and about 20,000 ha in West Bengal. Besides these two states, similar practice can be extended easily to the Khar lands of North Kanara District in Karnataka State and the Kazhan lands in Goa. In other states, there are no commercial prawn culture activities of any sort at present.

However, during last two years, considerable interest has been evinced on prawn culture programmes and steps are being taken to set up a few farms on pilot scale by almost all the Maritime States and Union Territories. Under a centrally sponsored scheme, the Departments of Agriculture started a brackishwater fish farming project which envisages culture of prawns and fishes in a 50 ha brackishwater farm area in each of the states. Following the demonstration carried out by the Central Marine Fisheries Research Institute, Central Inland Fisheries Research Institute and the All-India Coordinated Research Project on brackishwater fish farming, several private entrepreneurs are now coming forward to take up the enterprises. The Marine Products Export Development Authority is also endeavouring to promote prawn culture.

Assets of prawn culture

The foregoing brief review indicates what little we have so far done in the field of prawn culture. However, our country is blessed with the basic resources such as suitable land-cum-water areas, cultivable species and human resource for undertaking prawn culture on a large scale.

Water resources

All along the 6100 km long coastline of our country, there are numerous bays, lagoons, estuaries, backwaters, brackishwater lakes, mangrove swamps, the extent of which is estimated at about 2.6 million ha. The coastal waters, bays and lagoons as well as the estuaries and brackishwaters are generally highly productive and have a dynamic environ-

ment. The physiography of our coast shows great diversity. There are extensive mangrove swamps in the northwest and northeast coasts, which are also characterised by large tidal gradients. Marshy soils occur in the coastal regions of Orissa, Sunderban and West Bengal. In certain parts of the coast, as in Kerala, heavy erosion takes place during southwest mosoon. However, the coastal waters, by and large, form ideal grounds for prawn culture. On the inland sector, we have plenty of fresh water source, to the tune of 1.6 million ha, suitable for fresh water prawn culture.

Cultivable species

About 55 species of prawns and shrimps belonging to Penaeidae (27 spcies), Sergestidae (3 species), Oplophoridae (1 species), Palaemonidae (13 species), Alphidae (4 species), Hippolytidae (1 species), Pandalidae (5 species) and Atydae (1 species), that are either commercially important at present or commercially potential, occur in our waters. Several of these species, on the basis of the present knowledge, are not suitable for culture. Considering the available information on the biology, ecology and distribution, the following 11 species of penaeid prawns are found to be suitable for culture in the salt waters of our coastal zone.

1. *Penaeus monodon*
2. *P. indicus*
3. *P. semisulcatus*
4. *P. merguiensis*
5. *Metapenaeus monoceros*
6. *M. affinis*
7. *M. dobsoni*
8. *M. breviconis*
9. *Parapenaeopsis stylifera*
10. *P. sculptilis*
11. *P. hardwickii*

In the fresh water, 4 species, namely *Macrobrachium rosenbergii, M malcolmsonii, M. idella and M. choprai* are available for culture.

All the penaeid prowns mentioned above though marine in origin, are endowed with a naturally evolved life pattern which is partly spent in the sea and partly in the shallow inshore waters, estuaries and backwaters. The exception to this is *P. stylifera* which completes its life cycle in the marine environment itself. The biological trait of immigrating to the coastal waters in the younger stage exhibited by these prawns, their relative faster growth rate and ability to withstand wide variations of the environ mental conditions during this stage of life add to their amenability and advantages of culture in the enclosed waters in the coastal regions. The species like *P. indicus, P. monodon* and *M. monoceros* have wide distributions along our coast. But the other species are of local importance as they are restricted to only certain regions of the coast.

Among the fresh water prawns, the giant fresh water prawn, *M. rosenbergii* is ideally suitable for culture as it grows to a large size. The species also occurs in the major river systems, such as Hooghly, Godavari, Pampa, Tapti and Naramada. The other species of *Macrobrachium* have restricted distribut ion.

Human resources

Total fishermen population of our cou-

ntry according to the 1972 census is 55,83,400, that represents about 1% of the total population of India. The active fishermen in the marine sector is about I million. Although reliable information on the number of fish farmers in the country is not available, it is opined that they constitute only a minor group. It is also indicated that a large number of fishermen are at present only partly employed in fishing and they could be engaged in fish culture activities.

Technological base.

As indicated earlier, appreciable advances have been made in the technology of prawn culture in recent years, and these technologies could be used for immediate development of prawn culture. It may be mentioned here that these technologies neither involve any sophistication of high degree nor are they complex and could easily be taken up by the fish farmers.

Strategy for future development.

The overall strategy for fisheries development of the country is to achieve higher production, increase employment potential and generate more income at the same time, not endangering the production potentials of the natural resources and ecosystems. In this context prawn culture can play a vital role. The results of recent field experiments have shown that a production rate of 1500 - 2000Kgs of quality prawns could be raised/ha/year. This is not only 3-4 fold increase in production over that of the traditional practice in quantity, but also production, quality wise, of selected high value species. Prawn farming is labour-intensive. Besides the actual farmers, a large number of persons can be employed in seed procurement/production, fishing and manufacturing of ancilliary equipments. As intensive culture envisages selective stocking, quality products which fetch high unit price could be obtained. It, thus, benefits not only the fishermen and their families, but also the overall rural economy.

Despite the recent efforts in R and D programmes in this field, there are large gaps and constraints which require immediate attention. Our knowledge and experience in this area are limited. An attempt is made here to identify the priority areas and the strategy that could be considered for accelerated development of the field.

An aquaculture Policy and planning is an essential pre-requisite.

An effective strategy in relation to specified objectives, targets of growth and achievement of economy is an essential pre-requisite for stabilised development of any field. It is already indicated that aquaculture in our country attracted the attention of our planners only in the latter half of the Fifth Five Year Plan. Though the importance of aquaculture has been realised now, it is apparently yet to make any appreciable dent in several states. This is mainly due to trade-off towards capture fisheries. For the quicker development of the field, it is essential that clear policies and planned projects with defined odjectives and resource allocation be evolved. It is also essential to pursue constantly

the selected strategy so that the programmes are implemented successfully.

Mass production of seed imperative

One of the basic requirements in large-scale culture of prawns is the availability of adequate seed. While the seed prawns of a variety of species abound in nature, their availability depends on several factors such as the spawning success of the stock, survival of eggs and larvae and their recruitment to the seed fishing grounds. It is well-known that the larval abundance fluctuates widely from season to season and year to year. Timely availability of the seed assumes further importance in view of the short duration of the culture operation, as delay of even a fortnight affects adversely not only that particular operation, but also the subsequent ones. Further, in our endeavour to develop intensive culture, we require the seed of only selected species. Rao (1978), in his paper presented at this symposium indicated the quantities of seed required by different States to start intensive culture immediately. It is felt from our existing knowledge that only 1/10 of this quantity may be obtained from nature. The remaining seed requirement will have to be met from hatcheries. This problem thus takes us to the task of perfecting immediately the techniques of hatchery production of seed of selected species of prawns. As our knowledge on the distribution and abundance of seed in several parts of the coast is scanty, it is also necessary to undertake a detailed survey of the seed resources along our coast.

Establishment of hatcheries requires huge investment and trained personnel. It may not, therefore, be possible for the farmers themselves to set up the hatcheries. A viable strategy will have to be developed by each of the States to set up the hatcheries and a proper agency should be entrusted to implement this programme. It is also necessary to develop a suitable technology for transportation of seed produced in the hatcheries and their distribution among the fish farmers.

Species selection for intensive culture

Although we have a number of penaeid prawns suitable for intensive culture, *P. monodon* and *P. indicus* are important from the national point of view because, these species occur on both the coasts and grow excellently in confined waters to a marketable size within a short period, could withstand wide changes in the environment, and are in great demand in the export market. However, of the two species, *P. monodon* is apparently more preferred. This species has advantages over *P. indicus* on account of its large size and hardiness. However, their resource in the wild is relatively of lesser magnitude and their seed is scarce. Nevertheless, it has a great furture not only as ideal species for culture in different types of ecosystems but also as a brood stock for evolving suitable hybrid varieties for our different ecosystems. Among the other prawns, *P. merguiensis* is a potential local species in Ratnagiri/Goa region and *P. semisulcatus* in the south-east coast.

Research need.

Modern/aquaculture of prawns has emerged as a multi-disciplinary science involving biology, ecology, physiolgy, micro-biology, botany, water chemistry, engineering,field technology, pathology, genetics, economics, socioloy, etc. as it includes several aspects such as, selection of species, survey and location of sites, construction of farms, controlled breeding and seed production, feed development, culture operation, monitoring of the stocked prawns, control of disease, maintenance of water quality, harvesting, processing, marketing and socio-economics.

Recent strides in the technology of prawn culture have definitely helped to project the potentials of the sector and its feasibility. Nevertheless, there are large gaps in our knowledge which require priority attention. Several new areas and systems will have to be worked out to establish prawn culture in an organised industrial magnitude. Immediate need of perfection of techeniques on hatchery production is alredy stressed in the context of our efforts to meet the large quantity of seed requirements. The development of large scale hatchery system needs several technological inputs. The most important of these are domestication of the selected species, improvement of the stock, development of live food organisms, artificial feed, control of disease and parasites, maintenance of water quality etc. All these aspects need intensified research efforts, keeping the local conditions in view.

In field operation, selection of suitable sites, designing and costruction of farms, regular monitoring of the stocked prawns, prevention from pollution damages, harvesting and farm management are important. As the physiography of our coast varies from region to region, detailed survey on the ecological conditions and tidal amplitudes is essential to select suitable sites. We have very little information on engineering aspects of farm construction. This being location-specific, an intimate knowledge of the area is required. Directed research on various farm engineering problems will have to be initiated immediately.

Polyculture.

It will be advantageous to develop integrated culture of prawns and suitable compatible species of fishes such as mullets, milkfish and pearl spot for the optimum utilisation of the pond water ecosystem. Techno economic feasibility studies have given encouraging results and wide-scale adoption of polyculture where fish seed is also available should be more remunerative to the prawn culturists.

Environmental management.

Consequent on rapid urbanisation and industrialisation, many of our coastal areas are increasingly subjected to pollution of various types. Continuous monitoring of water quality and prevention of the stocked prawns from pollution damages is very essential for successful farm operation. Similarly, we have very little information on the parasites and diseases of prawns. Quite a lot of research will have to go into these fields.

Harvesting technology

It is a common experience that, the stocked prawns cannot be harvested at a single operation. In the context of intensive culture in large areas, the harvesting technology to catch all the prawns in the fields is necessary. We have also very little experience in the management of large farms which require a knowledge of all the inputs that go into the culture operation and an integrated approach. Investigations on these aspects will have to be taken up on priority basis.

In addition to the above, scientific back ground on socio-economic and legal aspects relating to prawn culture is very meagre. Large scale culture operations may bring in several legal complications relating to leasing and licensing policies, rights of water areas, conservation of the resource etc. Periodic evaluation of the impact of the new technologies introduced and the development taking place on the social set up is essential to formulate further programmes. These aspects also require scientific investigation to promote culture fisheries activities and to formulate further development programmes.

While the overall strategy of research in prawn culture may be to obtain comprehensive information on various aspects of culture systems and the techniques involved, it should be based on a technology that could be adopted by our illiterate farmers and within their economic capacity.

Transfer of technology.

i) Training needs:

Success of prawn culture depends largely on the efficiency with which it is carried out, and the personnel involved in it. The development and operation of prawn culture on modern lines require trained personnel of different categories. In the accelerated programmes, large number of research and technical personnel are required to carry out advanced research on different aspects of prawn aquaculture and to solve the technical programme; managerial personnel with technical as well as administrative knowledge are essential to manage the prawn farms; and a large number of skilled operatives in seed procurement/production, in the field culture operation and fishing will be engaged when intensive culture is taken up. The training needs of these different categories of personnel are varied. At present, there are very little facilities to impart training at different levels. Training of fish and prawn farmers is being offered at the two Krishi Vigyan Kendras, one at Narakkal for mariculture and other at Dowli for inland fish culture. However, considering the large number of fishermen to be trained that too in their local languages, these two Krishi vigyan Kendras may not suffice. Intensive training facilities will have to be developed immediately by each of the States, so that, the trained operatives are available when other infrastructure facilities are built up. In certain aspects such as seed production and hatchery management, farm management and fish pond engineering, subjectmatter specific training. programmes may be imparted at different centres. The immediate strategy in this field shouid aim at providing

training facilities to fish farmers under a crash programme.

ii) Extension service

Imortance of extension service in transferring the technology developed by the research Institutes to the field, in widely propagating it among the actual operators and end-users and in providing consultancy and advice to fish farmers need not be emphasised. One of the major reasons for the slow pace of development of prawn culture is the inadequate extension service. An integrated approach involving the Research Institutes, Fisheries Departments, and the developmental agencies must be taken up immediately to demonstrate the techno-economic feasibility of prawn farming. Development of an efficient extension service and its strengthing needs priority attention.

Area devlopment

Prawn culture activities could play an important role in area devlopment, as they are essentially based in rural areas. In order to culture prawns, extensive areas are not required; they can be grown well in small water bodies such as in the shallow canals in the coconut groves. Under an integrated system, a fisherman family can grow coconuts on the bunds or in the adjoining land area to the pond, maintain livestocks like pigs, goats or ducks and culture prawns in the small ponds. This integrated farming system, utilising the entire land and water ecosystems would maximise production out put and benefits. Our devlopment profiles, therefore, should give priority for such an integrated farming system to usher quick rural devlopment and to improve its economy.

Scarce flow of finance is a constraint.

Prawn culture being a new field in the fisheries activities of the country, there is some hesitation to invest and promote the enterprise, particularly by public and private finance. This is mainly because of the lack of adequate information on the economic viability of prawn culture. However, attempts are being made to demonstrate the economic viability of prawn culture to the entrepreneurs and financing agencies. It is also essential to educate the fish farmers on the different credit facilities available under various schemes, and on the procedures to make use of these facilities for developing prawn culture. It is neeessary to evolve simple procedures avoiding the delay factors, for the grant of credit facilities to the fish farmers.

Prawn culture and rural development.

It is well-known that among the aquatic organisms cultivated at present, prawns occupy a high place. obviously due to their demand and price. The importance of this culture for promoting rural development, as a means of providing employment to those unemployed in rural areas and as a means of improving rural economy is now being increasingly recognised. In the context of our notional policy which is oriented towards rural development, our planning strategy in this area should be to

develop prawn culture quickly through integrated efforts of all those concerned in this field.

Public policy

In aquaculture development, it is imperative that we formulate a national policy with priorities safeguarding the interest of the fish farmers, agriculturists and the industry. If necessary, as in agrarian reforms, suitable aquarian reforms may also be formulated to help a national policy on aquaculture. Conflicts between land and water use, agriculture and aquaculture are to be resolved. A national strategy for prawn culture will have to be evolved within such a frame work.

Priority may be given to decide whether, as a national policy, selected coastal and brackishwater areas in each maritime state may be developed on the pattern of the Malaysian FELDA Scheme of human settlement, for developing prawn farms and apportioning them to the new and trained fish farmers. This may not only help to accelerate the development of prawn culture, but also motivate the industry to take up prawn culture in other areas on a large scale.

STRATEGY FOR COMMERCIAL SHRIMP FARMING

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Introduction

Asia and the Far East Regions have been the dominant areas of devlopment of the world aquacultuaral operations. The area of over 2 million hectares devoted to aquaculture in this region is the most extensive and the overall estimated production of over 2 million tonnes is the highest. But the widely varied stages of development of cultural operations are significant and stricking from the newly started to some with extensive areas and some with restricted areas but employing sophisticated methods for intensive operations for high valued species. There is scope for increased production, as there is over 20 million hectares available and suitable for devlopment and the production methods can be intensified, with increasing outputs over the prevailing practices in the region.

The brackishwater areas available in this region for aquaculture in the different countries are estimated as follws:-

	HECTARES
Bangladesh	4,76,000
India	27,30,000
Indonesia	60,00 000
Korea	4,52,000
Malaysia	3,75,000
Pakistan	6,82,000
Philippines	4,93,600
Sri Lanka	2,78,000
Thailand	41,87,000
Vietnam	5,00,000

(Source - IPFC working party, 2nd meeting. 1974)

Mangrove forests support a characteristic fauna including crabs, penaeid prawn juveniles and different species of molluscs. Certain species of penaeid prawns are dependent on mangrove forests for shelter during their early stages. These species include *Penaeus indicus*, *P. merguiensis* and *P. monodon*. Most species of Metapenaeus will live in backwaters even after eradication of the mangroves. Certain amount of correlation has been observed in some of the countries between mangrove forests and prawn fisheries as indicated below: *

	Prawns tonnes/annum	*Km^2 mangrove*
Mozambique	2,309	858
Malagazay	4,300	3,207
W. Thailand	3,300	1,500
Malaysia	32,000	3,000
Iran, Papua (N. Australia)	10,000	4,400

(* Source IOFC/DEV/74/34 – Mangrove Forests & Fisheries)

In India Mangrova forests occur in Rann of Kutch and Gulf of Cambay and in a

few marshy areas in Maharashtra and Karnataka. In the backwaters of Malabar a good portion of mangrove forests have been removed. On the east coast extensive and virtually unexplored mangrove forests exist in the deltaic areas and estuaries of the large river systems and in the Sunderbans. *P. indicus*, *P. monodon*, *P. merguiensis* and *M. monoceros* are closely associated with mangroves. It has also been observed that all species of *Metapenaeus* use mangrove creeks and backwaters as nursery areas.

In India there are some established practices in brackishwater aquaculture. Extensive paddy cum shrimp culture is a unique practice in certain areas like Kerala & Goa. Culture of shrimps in Sunderbans area is of importance. Brackishwater aquaculture is rapidly being developed in many other areas and methods of increased production through intensification have been identified recently.

General Conditions For Establishment of Prawn Farms.

The various conditions necessary for establishing prawn farms point out the need for careful study of

(1) the presence of commercially important species of prawns in the area;
(2) tidal range at the site;
(3) Location of the site in relation to the coast;
(4) the extent of the swamp or marshy areas;
(5) suitability of the bottom soil;
(6) presence of freshwater streams/ rivers draining into the swamp/ marshes;
(7) salinity of the seawater entering into the marshy area; and
(8) the rate of accretion per year.

In the efforts to develop areas like mangroves, estuaries, lagoons and backwaters for aquaculture with special reference to shrimp culture, the problems and constraints faced in most of the countries in the region are:

(1) availability of site for farming on long term basis,
(2) high cost required for development;
(3) inadequate technical know-how and lack of qualified technicians, managers, specialised skilled workers and extension workers;
(4) insufficiency and uncertainty of supply of seed of culturable species for increasing acreage and intensification of management;
(5) need for suitable and cheap food for raising selected species;
(6) problems of pollution;
(7) necessary funding for devlopment; and
(8) lack of devlopment incentives.

Constraints and Problems in the Shrimp Farming

Taking note of the interests and increasing efforts to take to brackishwater prawn farming, the various constraints met with in the different countries, and the need for taking effective steps to adopt a bold strategy for commercial shrimp farming in India, it is necessary to take immediately certain policy and administrative decisions. The major areas will be in relation to:

(1) selection of sites in the different regions of the country depending on the

conditions obtaining in these regions;
(2) allotment of sites and land on long term lease and the terms and conditions of such lease;
(3) preparation of the farm including fertilisation measures;
(4) devlopment costs and approval of lay out and plan for the farm;
(5) supply of prawn seed and juveniles from natural sources in the first phase and agencies for such supply and protection of these sources of supply;
(6) devlopment of hatcheries and prawn seed farms in selected regions by suitable agencies;
(7) training of technical and management presonnel at different levels;
(8) conservation and management measures - including preventive steps against possible pollution;
(9) sources of funding-depending on the intensity and extent of farming operations.

Selection of sites and allotment

(a) The State Government and the Central Government Departments viz Revenue Departments, Forest Departments Excise and salt departments, the Central and State Fisheries Departments and Institutions have data on the sites in the estuaries, tidal flats, mangrove forests, salt flats and deltaic areas. The areas for which full data are already available should be classified according to their suitability for prawn cultivation, based on the criteria spelt out. The remaining areas should be surveyed quickly within a period of five years.

The preference for farm sites should be over other sectors, like salt based industries or chemicals; the allotment should take note of the need for free entry of juveniles and safeguarding the ecological systems especially mangrove swamps and breeding of shrimps and their natural entry and growth. In each State a special co-ordination committee should be established not only for identifying the areas but also for allotment of the sites, within a period of three months after receipt of applications. The general guidelines and criteria should be spelt out clearly immediately.

(b) Regarding the allotment of sites, the conditions in estuaries and tidal flats vary to a great extent depending on the extent of estuaries, the tidal amplitude and their force. For instance, in the regions north of Bombay - e. g. Gulf of Cambay and Gulf of Kutch, the tidal ranges extend to over 10 metres and the currents are very strong. In the Ganges, the Brahmaputra, the Mahanadi, the Godavari and the Krishna estuaries, the tidal range is about 2 to 3.5 metres, the estuaries are wide and the current strong. On the South west coast, the backwaters and lagoons provide a different set of conditions and on the south east coast, there are wide areas of flat marshes and swamps. Salt marshes are in plenty in the south east and north west coasts. Such varying conditions call for decisions on manageable extent of areas and the necessary bunding and constructional skills. In the northern areas on the East and West Coasts large areas from 100-200 hectares may have to be allotted but in the southern areas, 5-10 hectares may be sufficient.

The sites suitable for prawn farming

hould be given on a long term lease or minimum period of thirty years as onsiderable expenditure is involved in uilding up bunds. sluices, drainage etc. n a phased manner.

Priorities are to be given for such allotment to public, cooperative and private sector taking note of the financial strength and organisational and management skills. Agencies with capacity to mobilise local manpower and fishermen will also have to be considered. The involvement of local community fishing in these regions will be an additional asset; such personnel at different levels should be trained.

The terms and conditions should cover aspects relating to protection of the ecological systems, for encouraging reservation of breeding and nursery areas, conservation measures, prevention of pollution, construction of nurseries etc.

The layout of the farms and nurseries should be got approved and such approval should be granted by the coordinating agency within a period of two months. The State and Central institutions should give technical advice to the prospective farmers.

Development costs and sources of funding.

The Central Marine and Inland Fisheries Research Institutions should prepare model layouts and general estimates for each state and for the different sets of conditions obtaining in each state. These layouts should cater to the smallest economically viable unit to medium and large scale farms. Besides the layout, the preparation of the farm, fertilising the water and adequate measures for safeguarding the shrimps and fish should also be covered in this area.

Supply of shrimp fry and juveniles.

In the early stages, it should be possible to meet the requirements of shrimp fry by collection from natural sources, but it will become necessary to develop suitable species by hatchery practices and scientific methods of rearing the young ones to meet the increasing demands. Adequate provision should be made for raising them in a section of the farm by a phased programme. It is desirable for an Agency to build up shrimp nurseries and also a team for providing the fry and juveniles and extend technical services in this field. Supply of fry and juveniles on commercial basis by a selected few agencies may be encouraged for each region.

Development of hatcheries and prawn seed farms.

Steps will have to be taken even now for the development of hatcheries and prawn seed farms, as a large number of trained men and skilled workers on the field have to be built up for each state. These activities require time and it should meet the increasing demands which will be generated in the next five years.

Such practices will also lead to devlopment of suitable feed for the different stages of shrimp in different sets of conditions.

Prawn seed and prawn feed will have to be devloped on commercial lines,

and they will provide subsidiary and ancillary occupations for the people in the area.

Training Programmes

It will be evident that trained personnel will be required in each state for

(a) survey and selection of suitable sites for prawn farming;

(b) construction of bunds, sluices and and engineering aspects of the farm; and

(c) preparation of the farm.

The manpower required for the above will have to be built up by the agencies of the State Governments and Central Institutions.

Besides, trained manpower is also required for farm managers, skilled technicians for collection of seed, feeding, fishing and transport and also skilled workers. The training of these technicians will have to be organised at the two Central Marine and Inland Fisheries Research Institutions and their substations and training centres and also at the State level training organisations. Short term and long term courses may be organised immediately. At the same time a team of Extension workers for shrimp farming should also be built up. Time is important and essential.

The ICAR, the Agricultural Universities who have facilities for this type of training and the State Fisheries Depts., should draw up schemes immediately and make necessary provisions for meeting the expenditure.

Conservation and management.

Aquaculture faces conflicts with other uses of land, namely agriculture, land reclamation, urban development, industries, conservation of forests, etc. The conservation and management measures required for the protection for shrimp nursery areas and their growth will have to be co-ordinated with the development measures of other sectors and at the same time realising the need for development of natural sources and safeguarding the ecological and environmental conditions.

A few instances are indicated. The reclamation of backwater and lagoons for agriculture (paddy cultivation) and cocconut plantations in the Kuttanad and the construction of Thanneermukam bund in Kerala have been responsible for adversely affecting the shrimp fishery in that area.

The urban area development in Bombay and the industrial wastes have completely destroyed the aquatic life in Thana creeks and estuaries. The industrial discharges of the rayon plant in Veraval, the fertilizer plant in Goa and the Titanium products plant in Trivandrum have affected the fisheries in the inshore waters and also the adjacent estuaries. The need for taking preventive steps in the discharge from the proposed rare-earths plant at Chavara is very important, as otherwise the rich prawn grounds in the back waters and coasts off Quilon and Alleppey districts will be affected adversely. The Water Pollution Board should handle these major industrial pollution problems than trying to stop the small quantity

of waste from small prawn freezing plants.

The important steps required are to develop suitable measures for prevention of depletion of fisheries and protection of natural nursery grounds by closed seasons and preventing capture of small shrimps by destructive gears and by other indirect methods to dissuade fishing of small sized shrimps. The Research Institutions should maintain a small team to study this aspect for monitoring the situation and recommending effective measures through education, training and extension and in association with fishermen and members of the industry.

The mangroves and the vegetation in the marshes and swamps in the estuaries are favourable for the nurseries and their removal will have to be judiciously done and the cooperation of the Forest Department and Salt Department is important. The leasing out of the shrub jungle for removal of firewood will also have to be regulated. In fact, the association of such lessees and labour with the lessees of shrimp farm areas and their labour will be advantageous.

With the reclamation of land for agricultural purposes, especially for paddy, the use of pesticides and their run off to the backwaters and estuaries supporting shrimp juveniles is another area requiring careful thought.

The development, coordination and regulation of the areas like tidal flats, estuaries, marshes and swamps, backwaters and lagoons, suitable for shrimp culture and fish culture may be entrusted to special development agencies, represented by the Revenue, Forests, Fisheries, Agriculture, Industries and Salt Departments and MPEDA. The possibility of utilising agencies like Sunderbans Development Authority in Bengal and Maritime Areas Development Authority, Orissa may also be considered.

Financing the shrimp farming operations and sources of funding.

Shrimp farming being an important activity falling within the purview of the maritime State Governments and being sources for development of the export sector, and as they are to be developed on commercial lines, the main sources of funding will have to be Commercial Banks and financial Institutions like ARDC, State Financial Organisations with State Government support and that of MPEDA.

The ICAR should finance fully the programmes relating to research, surveys, technical services and training of personnel at different levels, field services and extension. In each state, the state should provide land for the establishment of these services and should also participate to the extent of 50% of the cost. The state should establish one prawn seed farm and supply of feed and meet the entire cost and develop this centre for training.

The MPEDA should contribute towards a part of the cost of prawn seed and feed and the farming practices for the shrimp farmers, to a limited period. This organisation should also extend

facilities for meeting a part of the cost of training on improved practices followed in some of the neighbouring countries - for a period of about four weeks for at least 12 to 15 persons actually engaged in farm management and farm technicians, every year for three years.

Summary

A few measures required for taking up shrimp farming have been suggested for consideration and generating discussions at the symposium for adopting a bold strategy and for decisions on administration and policy. There will be some variations in administrative measures depending on the different conditions obtaining in the different states in the tidal flats, estuaries, backwaters and lagoons.

PULICAT LAKE AS A GIANT POND FOR PRAWN-CULTURE UNDER RURAL SCIENCE AND TECHNOLOGY

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Introduction

A strategy for a judicious exploitation of the brackishwater, prawn-seed and human resources around the Pulicat Lake, is proposed as a collaborative private sector and Government project, for prawn-culture.

There is a tremendous wastage of brackishwater and prawn seed resources, as well as the manpower resources of the fishermen and technical personnel around the Pulicat Lake, so that it could all be harnessed, for evolving a multi-purpose national project of commercial prawn culture on this lake, involving the collaboration of the State Governments concerned and the private sector, as discussed under the follwing three heads.

1. Pulicat Lake resources

Pulicat lake is the second largest brackishwater lagoon on the east coast of India, with an area of about 461 sq. kilometers, and it has an average penaeid prawn production of about 500 tonnes per year. Compared to the other areas suitable for prawn-culture in the country, the most desirable features of this lake are (1) its vastness is matched with its comparatively shallow nature with an optimum depth for prawn culture, (2) it is totaily unpolluted as yet from any scurce, (3) it abounds in larger and fast growing species of penaeid prawns like *P. monodon*, *P. semisulcatus* and *P. indicus*, (4) it is a natural lagoon with the right range of salinities for optimum growth of these species, and it has a narrow pass (mouth) into the sea, so that it is a naturally impounded area, (5) it has vast areas of unused low-lying land along the margins of the lake, that could be deepened and flooded for prawn-culture, and (6) it is easily accessible from Madras and has good transport facilities by road and rail, for marketing purposes.

2. prawn resources

Of all the species of penaeid prawns available in this lake, *P. indicus* is the mainstay and *P. monodon* and *P. semisulcatus* rank next in order, each species having two peak periods of catches in the year, depending on several parameters like the duration of the opening of the pass (mouth), hydrological and meteorological conditions in the lake. Postlarvae of all these species occur more or less through out the year but here again, there are two peak periods of ingression, monsoon and postmonsoon periods. Whereas postlarvae of *P. mon-*

don and *P. indicus* prefer the monsoon from October to December, the postlarvae of *P. semisulcatus* prefer the monsoon from January to June.

Juveniles of these three species are more commonly distributed in the shallower regions of the lake where it is less than two meters deep, preferablv with a weedy bottom,. The sub-adults prefer deeper waters, those of *P. monodon and P. semisulcatus* preferring weedy bottom, and those of *P. indicus* preferring sandy-mud bottom:

3. Human resources

(a) Fishing Communities: There are about 30 fishing villages dependent on this vast lake, each with about 100 families. Generally, there is a large number of children in each fishing family and they do not attend any formal schooling and even if they do so, they drop out early and join their elders sooner or later, on their family trade of caputre-fisheries. The very few that pursue upto the end of the secondary level, miserably turn out to the educated unemployed, having lost both the benefits of employment through their formal education as well as self employment through reluctane developed for traditional fishing. Girls, at what ever level of education they dropout, invariably stay at home.

In these circumstances, the most profitable education for a fishing community is education in their own trade or craft, namely in fishing. Instead of traditional capture fisheries, culture - fisheries would be not only appealing to the educated youth of the fishing communities, but would also be in tune with our current trend of multipurpose projects for prawn-culture and rural development. Boys from the fishermen families could be taught right from the elementary level, in the methods and principles of prawnculture and girls could be taught the hygenic methods of processing and preservation of prawn. Such a trade-oriented education alone, would utilise the expertise of the fishing communities which otherwise goes waste.

(b) Technical personnel: Aquaculture is an increasingly popular subject for fishery and zoology undergraduate students, and therefore, brackishwater aquaculture could be taught in all the coastal colleges and universities, as we, at the Madras Christian College (Autonomous) do at our Estuarine Biological Laboratory at Pulicat. Unfortunately, in practice, such so-called job oriented courses also go without any employment opportunities, so that even this technical expertise goes waste.

Strategy.

Considering the volume of the Pulicat Lake and its rich nutrients, the present output of penaeid prawn from this lake is far below its optimum stocking density or carrying capacity, the reason being nothing else but the extremely narrow pass (mouth), and its closure for the major part of the year, thereby preventing the ingress of the maximum numbers of postlarvae into the lake and also preventing the circulation of water. Therefore, it is recommended that (1) the lake pass (mouth) is widened and deepened and preferably

kept open permanently throughout the year, and even creating another pass (mouth) at the northern end of the lake, might also be thought of,

(2) in view of the vast population of the postlarvae perishing in coastal waters, being unable to enter the lake, fishermen could be trained to collect them and stock them artificially all over the lake, and the results of such artificial stocking could be followed for one or two years, for determining the optimum stocking density, mortality and growth-rates, etc.

Incidentally, this method of prawn culture would avoid the unnecessary expenses of laboratory-spawning and rearing upto the postlarval stages,

(3) conservation measures could be enforced prescribing the mesh size of the stake-nets, conventionally employed for prawn fishing in this lake,

(4) either the State Governments of Andhra Pradesh and Tamil Nadu could expand their culture programme, absorbing the technical personnel and educating the fishermen in prawn culture, or lease out the shallow brackishwaters for individual entrepreneurs on a co-operative basis, or the private sector could initiate large scale programme for prawn-culture cum trade-oriented rural education and development.

If this highly resourceful Pulicat Lake is utilised for such a mammoth prawn-culture cum crab oyster and fish-culture programmes, for which also this lake is best suited, it would be the finest example of a multipurpose aquaculture project in our country.

AN APPROACH FOR THE DEVELOPMENT OF BRACKISHWATER PRAWN FARMING IN TAMIL NADU

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Introduction

In India, the increased fishing pressure on natural prawn stocks in the seas and the reduced yield from some of the traditional prawn grounds have served to focus special attention of the maritime states on culture of marine prawns as a means to get more raw materials for the lucrative marine products export industry. The stiff competition for catching prawns in the inshore grounds in Tamil Nadu has lead to skirmishes in the fishing grounds between catamaran and mechanised boat fishermen and the Government and fishery administrators have a tough time to settle the problems.

Apart from the potential for earning foreign exchange from the culture of prawns, it is only of late, that the role of culture of prawns in integrated rural development has been recognised as an important means of generating rural employment by utilising the unutilised brackishwater and low-lying coastal areas for production of prawns. In the present paper, the strategy to be followed for the development of aquaculture of marine prawns in Tamil Nadu is discussed.

Background information

Tamil Nadu is endowed with vast potential for prawn culture in brackishwaters. The brackishwater resources of the state have been estimated at 80,000 ha and of this 27,000 ha can readily be brought under prawn farming. In addition 1,20,000 ha of cultivable waters in the form of abandoned salt pans, coastal lagoons, low lying coastal areas etc. are also available.

Investigations carried out on the prawn seed resources of some of the important brackishwaters in the State have given encouraging results. From the overall picture of the seed resources of the state, it can be safely assumed that, to begin with, there will not be any dearth of seeds of *P. indicus* for culture purposes.

However, the seed resources of *P. monodon* are limited and it will be sufficient to meet only a part of the demand. In the districts of South Arcot, Ramanathapuram and Tinnelveli, seeds of *P. semisulcatus* are available in large quantities. Seeds of *P. merguiensis* are also available in Muthupet swamps.

Unlike in the States of Kerala and West Bengal, brackishwater prawn farming is not pursued in Tamil Nadu except in the experimental ponds of the Fisheries Department and in some of the salt pans in Kannyakumari District and the

total aquaculture production of prawns in Tamil Nadu is negligible. It is evident from what has been stated above, that the vast cultivable brackishwater resources in the State remain unutilised. As witnessed during the implementation of inland pisciculture schemes, the category of brackishwater prawn farmers is also not existing in the State. Therefore, the main strategy for the development of brackishwater prawn culture will be:

a) to bring as much brackishwater area as possible under prawn farming;
b) raising a category of prawn farmers

According to the projections made by Prof. P. C. George and Dr. V. R. P. Sinha, out of the total available brackishwater area of 2 million ha in India, 0.45 million ha (22.5% will be brought under aquaculture by 1984 and the target of production has been kept at 500 kg/ha/year. Based on this projection, out of the total readily available area of 27,000 ha in Tamil Nadu, a target of 6075 ha is proposed to be brought under culture by 1984. It is also proposed to bring about 6,000 ha (5%) of the 1.2 million ha of other areas mentioned above under prawn culture. The targeted aquaculture production of marine prawn will be 9075 tons by 1984. This is designed to come from:

	Tonnes
Yield of prawns from 6075 ha of readily cultivable area @ 1000 kg/ha	6075
Yield of prawns from 6000 ha of abandoned salt pans, . . etc. @ 500 kg/ha	3000
Total	9075

The following species of prawns are considered to have potential for culture in brackishwater and marine ponds.

1. *P. indicus* and *P. monodon* (Brackishwater)
2. *P.semisulcatus* (Marine ponds)

Problems in the development of prawn culture

The most important problem areas in the development of prawn culture in Tamil Nadu are briefly given below:

Leasing of brackishwaters

Absence of appropriate legal frame work to facilitate the establishment of prawn farms is the most important bottle-neck in the development of prawn culture in Tamil Nadu.

The ownership of the brackishwaters in state are vested with the following agencies.

		Owneraship
1.	Poramboke lands	Revenue Department of the State
2.	Mangroves	Forest Department of the State.
3.	Abandoned Saltpans	Central Government
4	Patta lands	Private

More than 50% of the total brackishwater areas in the State falls under Government Poramboke The development programmes are greatly handicapped due to absence of a suitable policy for leasing the poramboke lands to the enterprising individuals and

agencies, who are ready to take up prawn culture.

Taking over mangroves for prawn culture

Mangroves forests cover a vast brackish-water area in places such as Muthupet and Vedarnyam salt swamps (Tanjore district) and Killai backwaters (South Arcot District.) These areas are reported to be highly fertile and the brackish-waters they enclose support a rich prawn fishery. Prawn seed resources of these waters are reportedly rich. The question naturally arises, whether these mangroves can be utilized for different productive activities which include prawn farming or on the other hand, have to be protected as precious natural wild eco-systems not to be touched. As no policy decision has been taken so far, the vast mangrove areas that can be utilized for aquaculture of prawns remains untouched.

Availability of prawn seeds.

Though significant breakthrough has been achieved in the spawning and rearing of penaeid prawns in hatcheries by the various Central and State Government Agencies, large scale production of prawn seeds for commercial purposes is yet to be achieved. Till such time as the hatchery produced larvae are made available to meet the demand for quality seeds, greater utilization of wild stocks of post larvae of prawns has to be accomplished. Most of the brackishwaters in Tamil Nadu are rich in seeds of commercially important varieties of prawns especially of *Penaeus indicus*. However, lack of information on the availability of the seeds in most of brackishwaters is a great bottle-neck in exploiting these resources.

The tiger prawn, *P. monodon* has many characteristics such as large size, fast growth and tolerance to low salinity which make it the most favoured species for culture. The seed resources of this variety are limited in Tamil Nadu

Knowledge in Farm Engineering.

Selection of proper site and suitable design for the construction of ponds and sluice gates are the most important factors that decide the success or failure of the farming project. Knowledge in the design and construction of brackish-water ponds is very much lacking. The low tidal amplitude of 0.4 to 1.0 m in the State is a specific problem which has to be taken into consideration while designing and constructing the ponds. Pumping of water will be required in most of the places. Lack of information on the engineering details connected with the construction of ponds, the type of sluice gates to be fabricated and the pumping of water are some of the bottlenecks in the development of prawn culture.

Other problems.

Other problems include gaps in our knowledge in the management, techniques, seed production, feeding and fertilisation, harvesting techniques etc.

Recommendations

All the brackishwater areas under Government (Poramboke) which are suitable for prawn culture, should be taken over by the Fisheries Department for rational

distribution among various agencies which seek them on long lease.

Fisermen, being the actual users of the brackishwaters, should be given priority in allotting the areas for prawn farming Brackishwater areas that can be converted in to prawn farms at reasonable cost should be given to fishermen/group of fishermen. The other areas which may cost a little more for converting them in to farms may be given private entrepreneurs.

A minimum of 5 ha is essential for making a unit economically viable and the leasing period may be for a minimum of 10 years.

To begin with the utilization of mangroves and low lying lands adjacent to mangroves which are barren or having scarce vegetation may be taken over from Forest Department for bringing them under Culture.

Raising a cadre of prawn farmers as done in inland pisciculture should be thought of. The brackishwater are frequented both by marine and inland fishermen. As much as the latter group exploit the brackishwaters to the maximum, while developing the prawn farming, suitable representation should be given to them in allotting lands, employment etc.

The construction of brackishwater ponds is capital intensive and the fishermen will not have requisite capital for the construction of ponds and farming operations. Therefore, Government finance should be made available to them. A Fish Farmers Development Agency type of organisation is essential to organise them, train them in farming and management and to provide them with supplies.

Private finance is forth-coming for the prawn farming projects in the State. But it will not be sufficient for the projected development programme. Institutional finance should be made available for this purpose.

A Brackishwater Farm engineering wing should be formed under the State Government to study the problems specific to the state and prepare suitable designs for the construction of ponds and sluice gates.

Wild seed resources in the brackishwater areas not covered so far should be explored so that greater utilisation of wild stocks of seeds could be accomplished. The possibilities of collecting the seeds from the surf in Palk Bay region should also be explored.

More technical personnel should be deputed to undergo training at Central Marine Fisheries Research Institute, Central Inland Fisheries Research Institute and Central Institute of Fisheries Education so that sufficient trained man power will be available for extension work. As per the recommendation of the Planning Commission, a training course has been started in the State to impart training to fishermen. As large numbers of private enterpreneurs are also interested in getting informed of the farming techniques, a short term training course should be conducted for them.

A great amount of rasearch is being conducted on shrimp culture by the various Central Research Institutes and State Fisheries Departments. Following are some of the important aspect of prawn culture which have particular importance for the state as well as to the whole of India and in regard to which intensified research is essential. Utilisation of abandoned salt pans and low lying sea fronts for prawn culturre where salinity is bound to go up by evaporation.

The suitability of *Penaeus semisulcatus* for culture in brackishwater ponds. Fertilization studies to understand the nutrient dynamics in brackiswater ponds. (The capacity of various types of fertilizer to stimulate pond productivity and support the growth of shrimp has to be determined.)

Harvesting of prawns in undrainable ponds. (Suitable methods should be developed for harvesting the prawns efficiently). Effect of agricultural pesticides and herbicides on shrimp growth and survival.

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STRATEGY FOR THE DEVELOPMENT OF COMMERCIAL SHRIMP FARMING IN KERALA

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Introduction.

India occupies a unique position in the World as the largest producer and exporter of Shrimps and the major portion of India's production and export of shrimps is contributed from Kerala. Kerala has great potentialities for the further developement of prawn fisheries. The present level of prawn production from marine waters is mostly contributed by the inshore waters. The prawn production fromthe inland water resources is largely confined to what is popularly called the prawn filtration from paddy fields as well as the backwater fisheries of the state. Therefore, it is imperative to evolve a proper strategy for the optimum exploitation of the existing prawn fisheries and also to make the best use of the available inland water resources for starting prawn farming on a commercial scale.

Backwaters of Kerala

The main brackishwater fishery resources of the State are distributed throughout the entire coast-line which extends to a length of 590 K. M. There is also a long chain of backwaters lying almost parallel to the coast. The backwaters of the state consist of inter-connected iagoons, bays and swamps penetrating into the main land. The estimated area of the brackishwater in the State is approximately 2,42,800 hectares. The largest of these backwaters is the Vembanad lake running into a distance of 96.5 K. M. from cranganore in the north to Alleppey in the south, and is known to cover a total water area of about 25,600 hectares.

The northern portion of the Vembanad backwaters is called the Cochin backwaters and upper reaches of the Cochin backwaters are connected to the Arabian Sea. This backwater also gets fresh water from the Periyar river in the north and Pamba river in the south, in addition to a larger number of irrigation channels, drains and riverlets. Out of the total number of 44 rivers, 41 rivers are west flowing rivers, the barmouths of which contribute a rich prawn fishery, in addition to other brackishwater fisheries.

Fishermen Population and Fishing Implements.

According to the 1972 Live Stock census the total fishermen population in the State is 5.508 lakhs. This consists of 2.789 lakh adults. Of the 2.789 lakh adults, 1.40 lakhs form male members. The fishermen actively engaged in fish-

ing operations are 1.105 lakhs. Of this, 0.673 lakh are having full time employment and the remaining 0.432 lakh are getting part-time employment only. The different types of gears commonly used by inland fishermen can be classified as fixed nets and free nets. They mainly consist of stakenets, China nets, cast nets and other types of free nets. The craft in common use are dug out and plank built canoes.

Strategy for the development of Prawn Farming.

The strategy for the development of commercial shrimp farming in the state should therefore consist mainly of providing the necessary infrastructure for the effective utilisation of these abundant brackishwater resources and secondly the production of prawn seed by collection from natural sources and by artificial breeding. The technological and scientific developments already achieved in the field are adequate to facilitate successful shrimp farming on commercial basis. The Kerala State Government, Central Marine Fisheries Research Institute and Marine Products Export Development Authority have undertaken joint studies by starting a Co-operative Intensive Prawn Farming Project at Narakkal in an area selected in the state fish farm. Another advancement in this field is the studies on prawn culture done by the Central Marine Fisheries Research Institute in the prawn culture laboratory at Narakkal established in the site handed over by the State Fisheries Department. As per the information made available on the studies conducted by the Institute, it has been proved that the average production per hectare in the seasonal fields could be raised from 700 kg. to 1000 kg. or more in an year. The studies made by the State Fisheries Department have also revealed that, even though the traditional systems of prawn culture is advantageous on account of the least expenditure involved, it is not altogether free from defects. For one thing, the indiscriminate and unorganised stocking reduces tha yield of prawns in the field. Secondly, since stocked prawns are not allowed to grow in the field for a sufficiently long period, low catches containing small size prawns are the inevitable results. Though mesh size has been regulated, this could not be enforced properly due to objections from fishermen. Therefore, for the development of brackishwater prawn farming it is quite necessary to enforce mesh size. Secondly the success in making optimum production largely depends on availability of sufficient numbers of prawn seeds of the desired species. This problem is to be tackled successfully by exploring the possibilities of tapping the natural seed resources in the estuaries, backwaters, creeks etc. lying adjacent and connected to the sea and by establishing prawn seed production farms in suitable locations. However, scientific and technological basis for commercial prawn farming has been laid, and the stage has now been well set for launching a comprehensive scheme of commercial fish farming.

Imparting technical know-how to the farmers:

Another aspect of the strategy is the dissemination of the technical know-how developed by scientific research in

the field of prawn-farming among prospective prawn farmers so as to convince them of the feasibility and economic viability of this venture. The State Fisheries Department has already started the implementation of a phased programme of training of the private pisci-culturists and the Village Extension Officers of the N. E. S. Blocks. Such training programmes can be extended to cover prawn farmers also by establishing training centres in coastal areas with a view to popularise the modern scientific methods of prawn farming. In order to accentuate the impact of this training scheme, a parallel scheme for setting up demonstration farms has also to be formulated and implemented. Establishment of demonstration ponds of appropriate size at suitable places through out the coastal regions has to be thought of. This demonstration programme will help to acquaint the enterprising private pisci-culturists with the practical methods to be adopted for the successful cultural practices of prawns in the available water areas. As stated above, a beginning in this direction has been made already with the starting of the new Co-operative Intensive Prawn Farming Project at Narakkal, near Ernakulam. This project being a joint venture involving the collaboration of the State Fisheries Department, the Central Marine Fisheries Research Institute, and the Marine Products Export Development Authority, it will be relevant in this context to make a reference to the first harvest of prawns cultured here. It was a bumper crop that was harvested on 2nd June 1978 from Narakkal Fish Farm under this project. The harvest has clearly demonstarted the technical feasibility and economic viability of intensive culture of selected species of fast growing prawns. Over one lakh seeds of *Penaeus indicus* .. "Naran Chemmeen" were collected from the adjoining canals during the middle of February 1978, and these were stocked at the rate of 40,000 in one of the one hectare fields and the rest in a larger field of 2.7 hectares. The stocked prawns grew to marketable size after 103 days of stocking. The harvesting of prawns from the one-hectare field, yielded a total quantity of 510.25 kg. of *Penaeus indicus* (Naran Chemmeen), 3 5 kg of *Penaeus monodon* (Kara Chemmeen), and 14.5 kg of *Metapenaeus dobsoni* (Poovalan Chemmeen), the total value realise being Rs. 13,658.85. This is the first time that such an intensive culture of *Penaeus indicus* was undertaken in a field of one hectare area and the feasibility and viability of the programme demonstrated to the public. A vertical and horizontal expansion of this programme will provide the scientific basis and psychological atmosphere for the systematic development of commercial prawn farming in the brackishwaters of the State.

Training.

Yet another aspect of our development strategy for commercial prawn farming is a well integrated programme of training and extension services. Regional training centres have to be started to impart intensive training to interested fishermen in scientific cultural practices of prawns.. Either the Fishermen Training Centres already functioning at Vizhinjam, Neendakara, Ernakulam, Beypore, and Cannananore under the control of

the State Fisheries Department can be utilised for this purpose by providing additional staff and equipments, or seperate training centres can be started. The programme of training has to be coordinated with a scheme of providing extension services for propagating the new ideas and know ledge. The Extension Wing recently created in the Directorate of Fisheries, Kerala State for rendering general extension services can be suitably re-oriented and strengthened by posting trained hands in prawn farming. An effective programme of extension service can be undertaken by this wing, and film shows, seminars, extension lectures etc. can be arranged. The extension staff should also render technical assistance to fishermen engaged in prawn farming by visiting their farms frequently and advising them on the timely measures to be adopted. A well established extension service system of this type will promote the prawn farming programme considerably and give a boost to the production of prawns in the State. The teaching and extension service staff can be trained in the Central Fisheries Training Institutes.

Phasing the programme.

It has to be pointed out in this context that the process of bringing the entire potential water area of the State under prawn farming has to be, of necessity, a long-term programme covering a period of about 20 years. The programme has to be suitably phased and implemented during the coming five year plan periods. As a first step, the Fisheries Department, Kerala has prepared a project report for the development of commercial prawn farming on the model furnished by the Government of India. The project has now been sanctioned by the Government of India and its implementation will be started soon.

Source of finance

Similar projects can be started in suitable locations in a phased manner. An encouraging fact worth mentioning in this context is that some banking institutions operating in Kerala have also come forward offering financial assistance to prawn farmers in the private sector for starting economically viable projects. What is required is to generate the requisite type of entrepreneurial talents and initiative to make the maximum utilisation of the existing favourable conditions for commerial prawn farming, utilising the finance available from Financial Institutions as well as Government.

Administrative measures.

Then there are some administrative measures which form the operative part of our strategy for the popularisation of prawn farming on commercial basis. Starting prawn farming projects by State Governments giving financial assistance to private farmers engaged in prawn farming, arranging for regular supplies of quality prawn seeds, rendering extension services etc. are the broad categories of administrative problems to be encountered in this matter. Government owned water areas have also to be leased out to interested prawn farmers for different periods extending upto 15 years. Fishermen colonies and settlements should also be started in

areas which are potentially important for the development of prawn farming. In areas where inland fishermen are concentrated fishermen co-operative societies can be organised and fairly large brackishwater and fresh water areas can be given to them on lease for undertaking prawn culture programmes.

Fresh water prawn farming in Kuttanad

The utilisation of the Kuttanad water-logged areas in Kerala for prawn farming deserves utmost consideration. There is a vast area of low lying lands and paddy fields filled with water either seasonally or throughout the year. For various reasons, paddy cultivation in this area has been found to be a difficult, uncertain and hazardous venture. Therefore, the question of introducing fish culture in this region, as an additional source of income to the paddy cultivators of the area has already attracted the attention of the authorities. The fresh water prawn *Macrobrachium rosenbergii* used to occur in large quantities in Kuttanad waters, but after the construction of Thanneermukkam bund, there is a considerable depletion of this fishery as the breeding grounds in saline water area were affected and the movement of prawn was obstructed by the bund: Therefore fresh water prawn farming in the paddy fields especially in Kuttanad Kari lands has to be attempted in order to enrich the fresh water prawn fishery. The prawn seeds have to be produced for this purpose to meet the demands of those who intend to take up fresh water prawn farming. Hatcheries for breeding prawn have to be started by Government in suitable locations and the prospective prawn farmers should be given financial and scientific assistance for prawn farming in the water areas owned by them or taken on lease.

Conclusion

To sum up prawn is a major item of our marine products exports. The sea food exports from Kerala was of the order of Rs. 57.62 crores in 1975-76 and the State's share of the all India Marine Products export in terms of quantity was 58%. In 1976, the national export trade of aquatic products has been commendable, registering an all time record of Rs. 179.86 crores, and the corresponding figure for 1977 is Rs. 179.74 crores only. In the case of export of frozen shrimps from India, there is a steady increase year by year, the quantity for 1976 being the maximum. In 1976 47952 tonnes of forzen shrimps were exported, valued to Rs. 160.65 crores and in 1977 it was 47239 tonnes valued to Rs. 156.22 crores. These facts highlight the crucial position as occupied by the prawn fisheries in the over-all spectrum of fisheries development in the country. Hence the development of commercial shrimp-farming is of utmost importance, not only in the context of the welfare of the fishermen community, but also in the larger interest of the country's export trade. It is therefore the most appropriate time to think of and evolve an effective strategy for the development and exploitation of this precious fishery wealth to the best advantage of all concerned.

PROSPECTS AND PRESPECTIVES IN PRAWN CULTURE

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Introduction

The fishing industry, during the past has been allured into prawn trade due to high price of prawns and ready export market. This led to the catching of large quantities of unmanaged prawn stocks from the Coastal Waters along the West Coast. These stocks fluctuated from one season to another during different years. A few years ago, total landings came down and doubts were raised that prawns stocks were being over exploited along Kerala coast. This problem was studied and the opinions were that the diminishing of the catch might have been due to change in the environmental conditions or over exploitation or both the factors acted simultaneously (George and Sebastian 1972). In addition, it is also well known that in some areas small and undersized prawns are caught in large quantities. The practice is alarming and can have serious implications on natural prawn stocks. On the East Coast the exploitation of prawns started much later, and is now concentrated off the coast of West Bengal, Orissa and Andhra Pradesh. These fishing grounds exist off the mouths of the major estuaries and lakes like Hooghly-Matlah, Mahanadi, Chilka lake, Godavari and Pulicat Lake (Rao 1976). In early stages prawns come to coastal areas, in the vicinity of the estuaries, at this state they are now being caught in large numbers. It is estimated that around 30 tons of juvenile prawns were caught, processed and exported, dring 1977 from Paradeep and Visakhapatanam. In United States the Industry buys these prawns at a price which varies around US $ 1.0 per kg. and makes extruded products.

The killing of undersized prawn adversely affects the industry and this practice which exists in many parts should be discouraged. It may also be useful to consider banning the export of undersized prawns. If we stop catching of juvenile prawns, there is a remote possibility that the income of a small number of poor fishermen can be adversely affected. However, these men can be more profitably rehabilitated by the trade for collection of prawn seed and starting aquaculture. In an overall picture, the total turnover of prawn trade has increased, but the industry has raised alarm about poor catches and the exploitation of prawns from the shallow waters appears to be very near the optimum sustainable yield from natural stocks. Therefore we must look for alternatives and prawn culture appears to be the solution for the future.

India has about 1.42 million hectares of

backwaters (Anon, 1976) and large number of salt works, fishermen in West Bengal, Kerala and certain other areas are familiar with traditional method of prawn culture of "Trapping and holding". The modern methods of culture have been demonstrated in different parts of India. It is estimated that by 1995 India will be able to raise the culture of prawns in a quantity equal to the present day catch of prawns from the sea.

The conservative estimates are that in one hectare about 2250 kg. of fish and prawns can be produced and the average income is Rs. 15,770 against an expenditure of Rs. 5000/- per hectare (Dwivedi and Reddi 1977). More enthusiastic estimates have indicated an income upto Rs. 32,570/- per hectare (Jhingran 1977). Inspite of wide variations in the levels of production to be achieved, all these data indicate that brackishwater culture is a viable industry and can be taken up as a developmental and commercial activity for providing increased food production and employment in rural areas. With our present day emphasis on rural development, brackishwater fish culture comes to play an important role. It is also necessary that with the available technology, equipment and resources, large areas of brackishwater are utilised for fish culture. In order to launch this programme effectively it is useful to have an assessment of our existing resources and technology and develop and approach by which the production can be started with minimum delay. Six steps are recommended: (1) Selective stocking and rearing, (2) Establishment of seed collection and distribution centres, (3) Commercial production of prawn fries under cotrolled conditions (4) Rearing of brackishwater prawn from seedlings to marketable size. (5) Prawn and fish culture in salt works (6) Low cost and simple technology for rural areas for farm construction through fishermen.

Selective stocking and rearing.

In Kerala and West Bengal prawn culture in rice field and *bheries* is known since long time ago. It is also known that in these areas the desired stocking material is available and can be collected in large quantities with simple methods. It is suggested that areas for stocking should be thoroughly dried, cleaned and manured and provided with screen at the inlets. This practice will ensure production of rich plankton initially and would not allow entering of undesirable species. It is also necessary that with each high tide fresh plankton is allowed to come in through the well guarded screens. The desired species of prawn and fish may be collected from the adjoining areas and stocked. The number of seed stocked should depend upon the environmental conditions including the availability of food from natural sources. The rate of stocking for prawn can be upto 50 thousand fries per hectare but a low stocking rate of 20,000 par ha., is recommended. By this practice it is estimated that from the existing centres the production can be doubled. This approach requires adoption of improved practices of pond management in the areas which are under culture at present. This is likely to be very easily acceptable because it does not require

large investments. In some parts of India particularly West Bengal this practice has been started and it is likely to expand very soon.

Establishment of seed collection and distribution centres.

The young ones of the culturable varieties of prawns and brackishwater fishes are available along the Indian coast. However, the availability of the juveniles of different species and their availability in different areas and seasons vary. The surveys conducted through the agencies of various States and Central Agencies have confirmed their abundance. Even today, seed is collected from these areas to meet the local requirements. However, at the All-India level no agency exists which undertakes collection of brackishwater seed in large number for sale to different parts of the country.

The collection and transport of milk fish fry for stocking has been in vogue in Tamil Nadu for more than fifty years. Recently experiments which were con ducted on transport of juvenile prawns from Kakinada to Bombay and Goa, have shown that prawn seeds can be collected and transported over long distances on the lines comparable to the Fish Seed Syndicate Howrah. The collection, transfer and supply of prawn can also be done by a national agency or by the Fisheries Departments, Fisheries Development Corporations of the different States themselves. Once the supply of seed is assured, like the inland fish culture, the brackishwater fish culture is also likely to gain momentum. In the first few years, till the alternate source for seed production and supply are developed, this agency should be able to meet the seed requirement of various parties who undertake brackishwater culture. It will be more useful if at least two agencies are established on each coast i. e. the East and West Coast. With the growing demand for seed, more agencies can be established. In this connection it may be mentioned that it will be also useful to maintain a seed bank for prawns. The seed banks are extremely useful for raising multiple crops in one year and also to meet the seed requirements, when favourable conditions do not exist in nature. Recent experiments conducted at the Central Institute of Fisheries Education have shown that if juveniles are transported in insulated boxes at lower temperature the survival is higher.

Commercial production of prawn fries under controlled conditions.

Various universities and Fisheries Institutes have bred different species of prawns under controlled conditions. Generally the production of fries has been on an experimental scale and the total number of fries reared was small (Thomas, *et al*. 1974, Raje & Ranade 1975).

Commercial production of fry has not been demonstrated so far and is not practised as an integral part of culture programme. If larger number of brackishwater fish farms have to be developed in India, it is absolutely necessary that we should be able to obtain stocking material of the desired species of fish and prawn under controlled conditions and from the sources which are

located near the farms. The question, apart from research and educational institutes was also studied by Hindustan Lever Ltd., Bombay. Their considered opinion is that with proper thrust it should be possible to establish commercial production centres for prawn fries in the future.

During the first phase, it is necessary that brood stock is collected from natural grounds. The method of collection, keeping them on board and transporting them to the experimental centres is extremely important and a meticulous task which needs trained personnel. The collected material should be bred and hatched under controlled conditions and reared upto stockable size. The experiments have been successfully done at Ratnagiri, at Bombay and a few other centres. The main problem is the food for earlier stages. Various kinds of foods have been tried. Artificial feed of appropriate particle size for young ones has also been recommended.

In spite of all these successes, one of the major difflculties in the field of brackishwater culture is the non-availability of prawn seed. Therefore the next stage is setting up semi-commercial hatchery to ensure the availability of prawn seed to the entrepreneurs. In this direction the Central Institute of Fisheries Education has started work and we have successfully bred *Metapenaeus brevicornis* and *Penaeus merguiensis*. The experiments have been repeated successfully. On 27. 4. 1978, this Institute had demonstrated a stock of about 1.3 lakhs post larvae (PL5) of *P. merguiensis* which were bred under controlled conditions. When they were about 40 days old they were stocked in Brackishwater Fish Farm at Goa and also in some rearing ponds at Saphala Salt works near Bombay. An important activity under the programme is development of new feed for different developing stages of larvae. The feed is an emulsion of Acetes sp. The important items are selective culture of Zooplankton, phytoplankton and *Artemia*. The institute hopes that the development of an artificial feed, culture of *Artemia*, modified aeration system and repeated success of rearing a large number of post larvae, which are more than one lakh from one pair constitute an initial step in starting semi-commercial hatcheries in India. The experiments have shown that given the proper facilities, it will be possible to set up semi-commercial hatcheries to ensure supply of prawn seed to different states and entrepreneurs.

Rearing of brackishwater prawn from seedling to marketable size.

The Brackishwater areas are zones of mixing of sea and freshwater environments. Their natural asset is high productivity and in addition each high tide brings in a rich supply of neretic plankton. This abundant energy present in the form of nutrients and plankton can be utilised through a short food chain for producing table fish and prawns. The smaller the food cycle, the higher is the yield. Fortunately, the prawns are primarily detritus feeders. Therefore, these species have a small food chain and are most effective for conversion of energy available at first trophic level into animal protein.

Another important aspect is that the backwaters are highly changing and a dynamic environment. There is an intricate balance between total organic decaying matter and hydrological parameters. Any strong change can break this balance and start pollution. In the polluted environments only the specialised fauna and flora like polychaetes mangroves etc. can servive (Dwivedi and Desai 1972). Therefore, the objectives in brackishwater farming are to take advantage of this environment by allowing in enough inflow of neretic waters and to utilise the available organic carbon and nutrients for production of fish and prawns. This condition is well utilised in "bheries" and other similar situations but no sooner a fish farm is constructed this balance is disturbed. Therefore in brackishwater farm ensuring enough supply of neretic waters and supply of supplementary food becomes important.

The problem of low oxygen and mineralisation can be solved by providing water circulation with air lift system. This helps in breaking down of detritus and better production of zooplankton and helps in faster growth and yield can be doubled. Supplementary food increases production, various types of supplementary feeds have been tried but feeding prawn on frozen *Acetes*, which is available in large quantities in some states presents new dimensions. They are cheaply available and they are readily eaten by prawns and their food conversion ratio has been reported to be good (Dwivedi and Hameed Ali 1977). Raising zooplankton under continuous aeration, presents interesting possibilities but the economics for large scale feeding has yet to be worked out.

Culture work undertaken at Kakinada has produced 2250 Kg of fish and prawn per hectare. In this farm the *P.monodon* has been grown to 230-240 mm in one year. The revenue estimates from this farm are rather conservative. Calculation of prawn prices at current rates of Rs. 40/- per Kg. will boost the income to Rs. 18,000/- per hectare for prawn and fish. While evolving working pattern at Kakinada, it was found that rural conditions permitted low inputs for stocking and artificial feed. The *methodology* developed here can be more easily adopted by a common fish farmer.

The CIFRI at their farm in Kakdweep had obtained a production of 1055 Kg with the artificial feeding. The estimated income was Rs. 32570/- per hectare (Jhingran 1977). During 1977 results of culture reported by CMFRI and by Tamil Nadu State Fisheries Farm, Adayar, Madras, presented a very optimistic picture.

It may be mentioned here that the work done at various fish farms is experimental and has many constraints. Therefore it will not be proper to use this data for studying commercial feasibility of brackishwater fish culture. Proper commercial feasibility estimates should be based on the working of Farms which are exculsively used as pilot project for aquaculture. These farms should also have certain minimum size to operate as economic units. The centrally sponsored scheme on Brackishwater Fish Culture, can be very useful in providing data.

Prawn and Fish Culture in salt works.

Salt making from sea is a very ancient practice in India, we have a large number of salt works. A part of these, salt works can be utilised for fish and prawn culture. A series of first few reservoirs and other areas where salinity does not exceed 40 ppt are suitable for growth. During 1975 the CIFE implemented a pilot project for prawn and fish culture at Sri Krishna salt works near Visakhapatanam. The survey of the environmental parameters of the salt works, particularly water circulation, salinity and temperature indicated that the first five reservoirs of the salt works were suitable for culture. The bunds of these reservoirs were strengthened and inlet and outlets were guarded with nylon-mesh screens in November, 1977. The prawn and fish seed were collected from the mouth of the creek and from the first reservoirs into which the water was pumped from the inlet canal. This reservoir served as collection ground for all the local varieties.

Approximately 25,000 *P. monodon* and 2,35,000 *P. indicus* 2.5 lakhs of chanos and Mullets were stocked. Regular sample nettings were conducted for growth studies. By the end of March, 1978 the *P. indicus* had grown to the size range of 170 to 180 mm *P. monodon* attained lengths varying between 150-200 mm *M. cephalus* 200 mm *Chanos* upto 250 mm *Lates* upto 280 mm (Dwivedi & Reddi 1978).

Four ponds of about 50 hectares yielded 1500 Kgs of prawn and 12 tons of fish. The cost of the entire operation was around Rs. 40,000/-and the income was more. The same entrepreneur who had started the venture at a cost of Rs. 40,000/- during 1977 ventured for projects totalling to Rs. 2.0 lakhs during 1978, (Dwiveddi and Reddi 1978). Thus at first stage culture can be started by using low stocking rates and the returns so obtained are encouraging. Culture in salt work in Gujarat at Mithapur and a few other areas has also been started by private organisations. In Saphala salt works M/S Konkan Sea Foods in collaboration with Central Institute of Fisheries Education, Bombay are also starting prawn culture in salt pans on experimental scale. The growth of *P. monodon* and *Chanos chanos* is encouraging.

Low cost and simple technology for rural areas for farm construction through fishermen

The low lying areas can be used for construction of brackishwater farms. The selection of sites for construction of farms is an important factor which determines the cost of construction and the recurring cost for maintenance. While selecting the site one of the major factor for consideration is the tidal amplitude, which increases from South to North. When tidal amplitude is more the backwater areas also tend to be more extensive. The examples are backwaters and mangroves along Saurashtra Coasts, and Sunderbans. Tidal amplitudes along with other factors also influences erosion and accretion processes which can damage no bunds. It also regulates flow of neretic waters in to the system and availability of oxygen and degradation of organic detritus and its regeneration.

Therefore, in the first instance, the effort should be selection of khar lands and semi protected backwaters. In these areas the cost of construction should not exceed Rs. 20,000 per hectare. The estimates of construction cost may go upto Rs. 1.0 lakh per hectare. If we agree to such high cost, it will be difficult for economically weaker fishermen to adopt prawn culture due to non- availability of finance. Therefore construction of expensive farms should be undertaken by the state and central agencies.

Later they can lease these areas for culture purpose to fishermen and fishermen cooperatives. However, our immediate object should be to develop areas which can be made suitable for culture at very low cost, in any case not exceeding Rs. 20,000/–per hectare. Most of the work should be done with manual labour and technology, suitable for rural areas is recommended.

It may be stated that at present prawn and Fish culture has reached a stage of take off and it can be easily extended to different parts of India. In prawn culture the planners, administrators, fishery personnel and entrepreneurs have an effective tool which can bring about additional food production and provide employment in rural areas. If properly used it can change the picture of rural economy in areas where estuaries and backwaters are abundant and also help in earning valuable foreign exchange.

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ADMINISTRATIVE ARRANGEMENTS FOR COMMERCIAL SHRIMP FARMING*

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Introduction

Despite the huge water area that can be brought under shrimp farming and the prospect of technological break-through in the matter of production of fry and culture to a marketable size, there are a number of administrative problems to be solved before any large scale commercial shrimp farming can be undertaken in this country. These are briefly, social, financial, organisational, legal and security problems.

Social Problems.

The Government policy is now directed to providing a more gainful employment and protection to the weaker sections of the community. Brackishwater fish farming has already been considered as an area, which can provide large scale employment to the fishermen and thereby bring about a general up-lift of the community. Planning Commission, while supporting the MPEDA's scheme for shrimp farming has impressed on the need for ensuring that the benefit goes to the fishermen.

It is true that many of the development schemes so far implemented in the fisheries sector have benefited only the marine fishermen and that too the more progressive fishermen. The little fish farming that is being done in the commercial sector is now in the hands of the relatively affluent group.

At the same time it is to be adjudged whether the stage is ready for fisherman to be fish farmers. Judging from the experience so far, it would be more reasonable to assume that for some more time their involvement would be in the form of trained farm labour rather than fish farm owners. However, a transition has to take place and a beginning has to be made wherein Government assisted fish farms are run under the collective ownership of the Fishermen. This does not, however, mean or imply restrictions to individuals, even at a late stage, in owning or operating a fish (prawn) farm. The question assumes significance only when it comes to lease or award of fresh settlement rights. It should be

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* The views expressed are personal views and do not in any way bind the Government or MPEDA to the approach indicated.

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remembered that no large scale construction or improvements to fish farms can be expected except under ownership rights or under long-term lease. Under the scheme "Fish Farmers Developing Agency", a 15-year lease period has been proposed by the Central Government and accepted by almost all State Govenments to enable farmers to put up fish farms and to realize a reasonable return during the 15-year lease period. The scheme has been working satisfactorily in the inland sector.

Government is also encouraging big industries to enter the field of deep sea fishing, with suitable safeguards for protecting the interests of the small scale operators. Similarly an approach can be taken in respect of large brackishwater farms requiring huge capital investment. A period of 15-year lease for this purpose should be sufficient to attract investment by the larger industrial groups, particularly, those engaged in the shrimp processing industry. In both these cases, the Government would be getting developed brackishwater farms after a period of 15-year lease. That would be a proper time to settle fishermen on small plots on the farms thus developed. The working capital requirement for the actual farm operation being mostly in the nature of labour costs, it would be within the financial resources of an ordinary fishermen to manage the small farm, of say 1 acre waterspread. However, since some of the services like ring bunds, water draining facilities etc. are common, it would be necessary to have a co-operative of the fishermen farmers, so as to attend to the common services.

Financial Problems.

Brackishwater fish farm construction is expensive. The farms are also susceptible to damages during cyclones, which are fairly frequent on the east coast. Any scheme for large scale brackishwater farming should take into account provision of finance and cyclone insurance.

As regards finance, banks have already shown considerable interest in shrimp farming proposals. At the same time the banks would require suitable feasibility reports as well as advice on the extent to which financing would be safe under specific conditions. MPEDA, under its scheme for shrimp farming, has made arrangements for both provision of suitable feasibility reports as well as estimation of finance requirements and economic viability.

Cyclone risk insurance is an entirely new concept and so far no reference to this has been made in any forum. Considering that large tracts of the entire east coast are affected by cyclones, it is necessary that suitable institutional arrangements in this regard are also evolved side by side with the brackishwater fish farming. Insurance Companies should be requested to make an estimate of the risk involved and to indicate the likely premium.

In the past, Government has been giving cyclone relief to the affected persons. Hence the alternate suggestion would be to bring brackishwater farms also within the category eligible for cyclone relief; in which case a seperate cyclone insurance may not be necessary.

Organisation Problems.

During the last one year a great amount of interest has been created within the country regarding shrimp farming. Organisational arrangements available are far short of the demand that may be placed by this sector. Assuming that out of a total 2.2 million hectares. only 1% is brought under Kara farming, 2% under Naran farming and 3% under mixed farming, during the next four years the fry requirement will be briefly as under:

Kara @ 20,000 per ha.	= 440 million
Naran @ 70,000 per ha.	= 3080 million
Mixed species @ 1,00,000 per ha.	= 6600 million
Total	= 10120 million

This coverage of 5% of the available water area would mean a requirement of 10120 million prawn fries. The figure, while highly academic in its computation, still underlines the need for a massive national programme to produce/procure and supply the prawn seed.

The normal approach would be to collect the fry from the natural environment. Unfortunately the known prawn fry resources, particularly, the Kara fry resources, are limited and localised. It is therefore, necessary that:

1. a nation-wide search for locating Naran fry resources should be launched.
2. the technique of artificial breeding, rearing and stocking of fry be perfected and prawn hatchery established in all States,
3. training facilities are provided in all states.
4. shrimp farming becomes a part of the Integrated Area Development Programme.

Legal problems

There are any laws, customs and practices, which come in the way of large scale brackish water prawn farming. In some States like West Bengal 'Bheries' are outside the land ceiling. There has been considerable amount of speculation about Government policy in regard to any ceiling/regulation of 'Bhery' fisheries of West Bengal. An atmosphere of uncertainty prevails and it is necessary to have a clear legislation in regard to the extent of water area that can be kept by an individual or family in each State.

Another legislation, which has direct impact on prawn culture in Kerala, is the Land Utilisation Act of 1967. Under this Act, the Government can direct every holder of land in the notified area to cultivate any of the "food crops". The term 'food crops" has been defined as to include Paddy, Sugarcane, Vegetable, Tapioca, Yam, Tea, Coffee, Cardamom, Pepper, Ground Nut and Banana Plantation; but not fish or prawn. In the Kuttanad area, farmers are required to cultivate paddy even-though it is reported to be uneconomical, whereas prawn farming, which is more economic is not covered by "food crops". Since prawn is also an item, culture of prawn should be considered as one of approved items of land utilization and prawn farmers should not be compelled to undertake paddy

cultivation to the exculsion of prawn farming.

Many irrigation systems have been constructed primarily with a view to developing paddy cultivation along the coasts at a time the scope for prawn farming was not appreciated. Over years the scope and economic viability of paddy cultivation have changed. In the Kuttanad area of Kerala, paddy cultivation is no longer economically attractive. In fact, many farmers have been doing paddy cultivation incurring a certain amount of loss, purely to comply with the requirement under the Land Utilization Act. The irrigation work undertaken in Kuttanad area has been primarily for retaining fresh water conditions to the maximum extent possible so as to undertake two crops of paddy. The main difficulty in utilizing this land for prawn cultivation, apart from the Land Utilization Act, is in view of the lack of adequate salinity. Even fresh water prawns require a certain amount of salinity to breed and re-populate in the area. There is an immediate need for working arrangement with the Agriculture and Irrigation Departments in meeting the salinity requirements of prawn farming.

Many of the swampy areas are considered as forest land. They do not produce any valuable timber and is often covered by shrubs of no consequence. Forest Departments generally maintain that the ecological balance, including annual rain fall pattern, would be affected if swamp areas are cleared off the vegetation. Here a realistic view has to be taken to see that prawn farming continues without affecting the environment. In Kerala, for instance, it is possible to raise a crop of coconut on the farm bunda, a crop of paddy in the submerged area during the rainy season and a crop of prawn during the non-rainy season. The total extent of vegetation would remain more or less unchanged by adopting such a pattern of mixed farming and these culture operations would be complementary.

There are many customs, which come in the way of economic shrimp cultivation. In Kerala, there is a practice that after the 31st March every year, prawn filtration grounds are free for all for fishing. If claims are extended to areas where shrimp cultivation work is undertaken, the farmer would be put to very heavy loss. It is necessary that suitable administrative order/legislation is available to protect the interests of the shrimp farmers.

Security.

One of the greatest threats in undertaking prawn farming is on account of security reasons. Unlike paddy, where the crop is ready for harvesting only for a shortwhile, prawn is fit for harvesting throughout the period of its culture. There have been instances of large scale looting and poaching of shrimp farms. Suitable safeguards will be necessary to protect the interests of the farmers.

A NEW SYSTEM FOR MASS REARING OF PENAEID SHRIMP LARVAE

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Introduction

The well known, Japanese system of large-scale, hatchery rearing of penaeid shrimp larvae depends on production of various species of diatoms as zoeal feed by applying specified doses of inorganic fertilizers in the culture medium itself and by supplementing these with cultured, live planktonic organisms like rotifers *(Brachionus* spp.) and with *Artemia* nauplii during mysis and earli post-larval stages (Hudinaga and Kittaka, 1967; Furukawa, 1972; Liao and Huang, 1972; Shigueno, 1972; Yang. 1975). Penaeid larval rearing as developed at Galveston, U. S. A. depends on production of selected algal species as separate cultures which are harvested periodically and fed to the larvae during zoeal stages and supplementing this with *Artemia* naupli. during mysis and early post-larval stages (Mock and Neal, 1974). In mass cultures, when natural food becomes scarce, artificial feeding with soyabean curd (Hirata and Wada, 1969), powdered, fat-free rice bran (Ishida, 1967), marine yeast (Furukawa, 1972), artifi cially produced, activated sludge (Imamura and Sugita, 1972), etc has been attempted with varying results. Fujimura and Okamoto (1972) used *Artemia* nauplii and strained flesh of skipjack (*Katsuwonus pelamis*) for mass rearing of larvae of *Macrobrachium rosenbergii* at Hawaii. Successful use of a compounded, formula feed, with or without the diatom *Chaetoceros*, for mass rearing of penaeid larvae has also been reported (Kurata and Shigueno, 1976), Reviewing the status of penaeid larval feeds Michael (1976) remarked that "artificial rearing has been based almost entirely on live, planktonic feed, supplemented with fresh tissue. It is likely these will be replaced with artificial, compounded diets in the future for technical and economic reason".

Shrimp culture in the Indo-Pacific region still depends largely on post-larvae and juveniles collected from natural sources. In the context of steadily increasing, export oriented demand for shrimps, large-scale culture operations have become important and mass rearing of shrimp larvae in hatcheries to meet bulk requirements of seed for stocking large commercial farms has become urgent. In none of the countries in the region, however, *Artemia* cysts, now essential for successful rearing of shrimp larvae, are available in adequate quantities. Developing a suitable cheap, artificial feed for mass rearing of penaeid larvae is, thus, of great importance in furthering programmes of shrimp cul-

ture in the region. Against this background a series of experiments were carried out during June-September, 1977, while on a brief visit to the FAO/UNDP Project on Brackishwater Shrimp and Milkfish Culture Applied Research and Training at the Brackishwater Aquaculture Development Centre at Jepara, Indonesia, and the results are briefly presented in this contribution.

Hatchery Facilities, Feed Preparation and Feeding

Rearing experiments were carried out in plastic pool hatcheries of 2–9 tons capacity, kept under a glass roof and provided with arrangements for continuous aeration and water exchange as and when required. Salinity of water ranged from 35 to 36 ppt. and water temperature from 28 to 31° C. The incoming water was invariably filtered through a 100 micron mesh filter box. Mature spawners of *P. merguiensis* and *M. monoceros* collected from the sea and a pond grown female of *Penaeus* sp. (very similar to *P. monodon*) induced to maturity by eye-stalk extirpation were successfully spawned to produce larvae for rearing. Small, non-penaeid prawns, *Acetes* spp. and mysids *Mesopodopsis* sp. were used as artificial feed for the entire larval phase, without any feed supplement.

Fresh *Acetes* were obtained from fishermen operating scoop nets or push nets along the coast, while, live mysids were collected from brackishwater ponds when they swarmed near sluices against the inflowing tidal water. These were frozen in convenient size blocks and stored in a freezer for future use. Desired quantities of the frozen material were blended with salt water, boiled, decanted and sieved through different mesh nylon netting (50 to 160 microns for zoea stages; 250 to 400 microns for mysis and early post-larval stages). Ordinarily a kilogram of raw material when processed as above, yielded about 0.80 to 0.85 kg of material that goes into feed suspension. Calculated volumes of this fine suspension are broadcast over the hatchery pool, ordinarily at 5 hourly interval, making five feeds per day. Initial dose of feed per day amounted to approximately 2 3 times the weight of larvae in the hatchery pool. As the larvae moulted into the succeeding stage, feed was increased by 50 70%. Slow exchange of 15 to 25% of the hatchery pool water was provided daily after the larvae reached the mysis stage. Exchange of fresh sea water was necessary whenever too much of food remained unconsumed in the medium.

Experiments and Results

Six rearing trials were carried out, four with *P. merguiensis* and one each with *Penaeus* sp (closely allied to *P. monodon*) and *M. monoceros*, utilising spawners as detailed in Table I.

Spawning occurred at night, within 4 to 8 hours after introducing the spawners into the hatchery pools. In most cases spawning was complete and the percentage of fertilisation high. Artificial feeding commenced at the first zoea stage. Details of feeding and progressive growth and survival of larvae are given in Table II.

TABLE-I

Particulars of Penaeid Spawners used for larval production

Culture No.	Species	Spawners used Source	No.	Length/wt. mm. g.	Spawning Success %	Number of Nauplii produced
1	P. merguiensis	Sea	1	161/32	100	141,338
2	,,	,,	1	193/60	100	369,292
3	,,	,,	1	185/55	100	267,800
4	,,	,,	3	189/50	100	
				173/42	50	386,800
				164/35	80	
5	*Penaeus* sp.	Pond; maturation induced	1	148	100	22,000
6	*M. monceros*	Sea	4	115-128 20-25	100	336,705

TABLE-II

Growth and survival of penaeid larvae in mass cultures with Crustacean fresh tissue suspension as feed

Hatchery	1	2	3	4	5	6
Capacity: Cu. M.	1.78	1.78	1.78	6.0	1.78	1.78
Sq. M.	2.50	2.50	2.50	10.0	2.50	2.50
Species cultured.	*P. merguiensis*	Do.	Do.	Do.	*penaeus* sp.	*M. monoceros*
Date of spawing	12-8-77	5-9-77	20-9-77	20-9-77	8-9-77	5-9-77
Date of hatching	13-8-77	6 9-77	21-9-77	21-9-77	9-9-77	6-9-77
N6 population	147,338	180,673	267,800	386,800	22,000	336,705
Zoea -I On	15-8-77	8-9-77	23-9-77	23-9-77	11-9-77	8-9 77
Population	143,519	118,074	299,156	421,273	-	314,214
Zoea -II On	17-8-77	9-9-77	24 9-77	24-9-77	13-9 77	9 9 77
population	140,583	94,408	-	-	18,856	-
Zoea III On	18-8-77	10-9-77	26-9-77	26-9-77	14-9-77	11-9 77
Population	140,464	89,050	274,274	415,293	21,315	225,920

Feed given during zoeal stages (g)	125.0	325.0	775.0	925.0	225.0	225.0
Mysis I On	19–8–77	12-9-77	28–9–77	27–9–77	15-9-77	13-9–77
population	94,288	62,335	141,589	403,079	21,375	110,400
Mysis II On	20–8-77	13–9-77	30-9-77	28-9-77	16-9-77	14-9-77
population	75,705	59,500	-	–	17,368	91,305
Mysis III On	22-8-77	14-9-77	1-10-77	29-9-77	17-9-77	16-9-77
population	85,220	56,992	61,454	353,203	18,407	83,974
Feed given during mysis stages (g)	225.0	325.0	2475.0	2375.0	325.0	500.0
Post-larval on	23/24-8-77	15-9-77	3-10-77	30-9-77	18–9–77	17-9-77
population	47,331	55,015	23,040	350,346	21,375	76,583
Feed given during post-larval stage (g)	150.0	125.0	625.0	875.0	125.0	175.0
Total feed given during culture (g)	500 in 11 days	775 in 9 days	3875 in 12 days	4175 in 9 days	675 in 9 days	900 in 11 days
Survival from N6 to post-larval (%)	33.5	30.45	8.62	90.57	97.16	22.74
Production of post-larvae per Cu.M. of water.	26,590	30,907	12,943	58,391	12,008	43,025

While introducing spawners into the hatchery pools, ordinarily water level was kept at 40 cm. depth. At nauplius-6 stage, water level was raised to 60 cm. in all the pools. In the smaller pools the level was further raised to 70. cm at zoea-I stage. In these pools, daily exchange of 0.6 to 0.8 tons of water commenced from zoea-II stage. By mysis-I stage water in the pools generally developed a greenish-brown tinge due to development of algae and diatoms. In hatcheries 1 and 3 aeration was provided through 4 concentric circles of perforated plastic tubing, laid at the bottom. In others air stones were used, 4 for each small pool and 13 for the larger pool.

It is seen from Table II that in good cultures, the newly hatched nauplii took just 9 days to attain the first postlarval stage. In such cultures, usually all the larvae moulted into the succeeding stage, almost simultaneously, indicating that water conditions and food were satisfactory. In cultures where feeding was inadequate or excessive at some stage, the larval life was prolonged to 11 - 12 days, moulting was not very regular often resulting in mixtures of two stages and survival was invariably low.

Discussion

Successful use of *Acetes indicus* for feeding fingerlings of *P. monodon* has already been demonstrated (Hameed Ali and Dwivedi, 1977). Exclusive use of *Acetes* and mysids as the only feed item for all the larval and early post-

larval stages in mass cultures of penaeid larvae does not appear to be on record. *Acetes* is extensively caught along the Maharashtra coast and is available in large quantities at relatively cheap rates. Acetes landings in Indonesia during 1975 amounted to 8,800 metric tons (FAO, 1976). Mysids in commercial quantities are caught along the coast in most places, and in brackishwater ponds they thrive and multiply into sizeable populations which can be collected easily.

As the only feed in the experimental mass cultures, *Acetes* and mysids had to be very carefully processed from fresh material as fresh tissue suspension of desired particle size. Daily addition of appreciable quantities of this feed in the limited volume of culture medium created serious water quality problems only when appreciable quantity of the introduced feed is left un-utilised. In such cases, even regular exchange of water did not lead to very satisfactory results. Such situations are avoided by regularly observing water conditions and feeding activity immediately before introducing each feed, and suitably adjusting the quantity of feed. When the feed is properly dosed and readily consumed, water qualities remained satisfactory with minimum daily exchange and routine aeration. The very high rate of survival of larvae under such conditions clearly shows that the food given is acceptable, assimilable and wholesome. While several more large-scale trials are to be carried out to determine the optimum particle size and dosage of feed at different stages for different species, the data presented in this contribution shows that successful mass rearing of penaeid larvae on an easily available, cheap artificial feed is easy and practicable, completely dispensing with the conventional practices of raising and maintaining larval live feed culture systems. The present results, thus herald a new system of penaeid larval rearing.

In the six experiments included under the present study, 1,334, 708 nauplii were reared to obtain 573.690 post larvae.This represents 43.98% survival. In Fig. I these data have been compared with corresponding data from Japan and Taiwan, showing that as a method the present one is much simpler and more effective than the conventional methods hitherto adopted for rearing penaeid larvae. It is seen from Fig. I that during zoeal stages there was hardly any mortality when artificially fed. The relatively higher mortality during mysid stages could probably be reduced by suitable manipulation of feed particle size and this could lead to significantly higher rates of survival at post-larval stage.

Mock and Neal (1974) have compared the operating costs for production of 1,200,000 penaeid post-larvae under the Japanese and American systems of larval rearing and these are examined in relation to the new system of larval rearing reported in this contribution (Table III)

Cost of gravid females and feed under the new system is extremely low and the production cost for 1,000 post-larvae does not exceed Rs.2 to 3. Technology for mass rearing of penaeid larvae is still undeveloped in India and

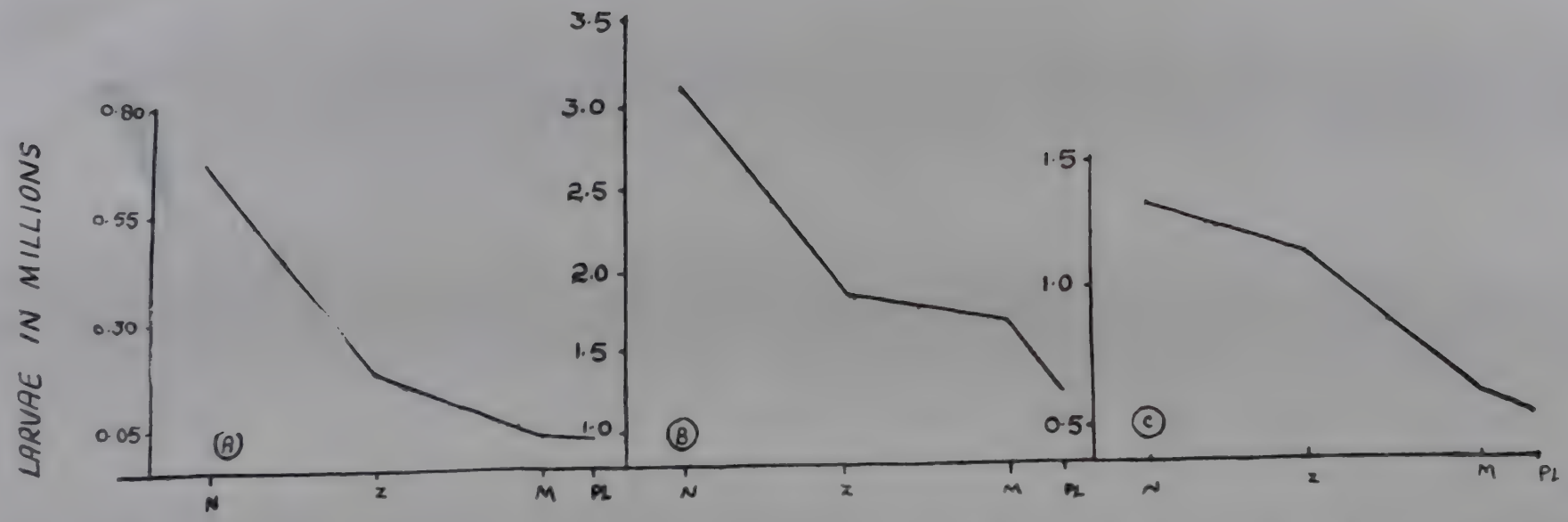

Fig. 1: Comparative survival of penaeid larvae under different systems of mass culture. A. Taiwan: (Liao & Huang, 1972). In four cultures of *P. monodon* 64, 934 postlarvae survived out of 750, 299 nauplii. Survival : 8.65%. B. Japan: (Shigueno, 1972). In nine cultures of *P. japonicus*, 12,820,000 postlarvae survived out of 31,433,000 nauplii. Survival: 40.78% C.Indonesia (Hameed Ali, 1978). In six cultures of *P. merguiensis*, etc 573,690 postlarvae survived out of 1,334, 708 nauplii. Survival: 42.98%

N-Nauplii, Z-Zoea, M-Mysis, PL-Postlarvae.

TABLE-III

Operating costs of three different systems of Penaeid Larval rearing, to produce 1,200,000 Post-Larvae

Japanese System Item of expenditure	Cost ($)	American System Item of Expenditure	Cost ($)	New System Item of expenditure	Cost ($)
Gravid females	2,200	Gravid females	550	Gravid females	20
Biologist (14 days)	672	Biologist (14 days)	672	Biologist (14 days)	125
Technician (Do.)	288	Technician (Do)	288	Technician (Do)	62.5
Fertilizers	20	Media for algal culture	187	Hatchery attender	28
				Feed raw material	10
Artemia -	40	Biologist for algal			
Utilities -	50	(20 days) culture	1,120	Utilities	55
		Technician (do)	480		
		Artemia -	20		
		Utilities -	75		
Total -	3,270	Total.	3,392	Total. -	300.5

at this stage availability of a simple, dependable system of larval rearing as the one presented in this contribution should be extremely helpful to encourage brackishwater shrimp farming in the country.

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